DOCUMENT RESUME

ED 337 698 CE 059 432

TITLE Skills Shortages in Europe. IRDAC Opinion.
INSTITUTION Commission of the European Communities, Brussels (Belgium). Industrial Research and Development Advisory Committee.
PUB DATE 90
NOTE 61p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Employment Qualifications; Foreign Countries; *International Cooperation; *Job Skills; *Labor Force Development; Labor Needs; Retraining; Secondary Education; Skill Obsolescence; *Supply and Demand; Technological Advancement
IDENTIFIERS European Community

ABSTRACT

In 1989, the Industrial Research and Development Advisory Committee (IRDAC) of the European Community established a Working Party on education and training issues relevant to industry. A subgroup on skill shortages considered the issue from the European and macro-economic point of view. It examined such skills shortages issues as demographic trends that will lead to tighter labor markets, need for higher educational attainment and new and multidisciplinary skills, changes in demand, and the impact of advances in research and development and technology. A number of sectors were examined to demonstrate the crucial importance of human resources and adequate skill levels. Wide differences between Member States were found. Data on educational attainment, skilled labor demand, and output of engineers and scientists suggested that the more developed regions in the center and north of Europe were in a much better position. The following recommendations were made to remedy some disturbing trends: continuing training for the existing work force; adequate skills for the young entrants on the labor market; a European investment in human resources, training tools, and technology; and understanding of skills requirements. (Appendixes include a glossary and list of 41 general references.) (YLB)

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Skills Shortages in Europe

IRDAC Opinion

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Skills Shortages in Europe

IRDAC Opinion

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FOREWORD

European Education and Training, Human Resources and Competitiveness

The Technological Explosion and Skills Demand

The decades since the World War II have been a period of rapid and accelerating technological change fuelling increased industrial productivity and economic growth. New industries have been created both in the manufacturing[1] and service sectors. The same **technological advance has created a global market place and global competition** which continues to increase with the technologically driven development of the economies of the Pacific rim and other newly industrialised countries.

Today, markets for most products are global in scope and for high technology products the markets are driven by product innovation. Global markets for low-technology products are driven by price; although labour and capital costs and exchange rates are important factors in price, so also is the function of **process innovation. High technology concepts can be applied to the production process to drive down costs**. Europe in general (as the U.S.A.) have fallen behind Japan in the application of technology to production concepts especially in mature and traditional industries. The West has only recently begun to develop a multidisciplinary science of manufacturing and to give its study sufficient attention in university research and education.

There is a further factor in this globally competitive arena. Competitiveness depends not only on creating and applying new knowledge to innovate the product and the manufacturing process but it needs to be achieved **faster** than the competitors. Thus the time from research output to application across industry is decreasing rapidly and this accelerated technology transfer is aided by collaborative working between industry and academy (or other research centres) or by movement of research workers from academy to industry.

> *For nations to succeed in the creation of competitive advanced technology based industries will necessitate the mastery of the process of rapid transformation of research results into innovative industrial applications. There are indications that Europe is lagging on this front. For example in the field of biotechnology it has been reported that the numbers of employees in new U.S. biotechnology companies increased rapidly from 20 000 in 1982 to 200 000 in 1998, with Europe, facing equal opportunities in the field of biotechnology, witnessing a much slower growth rate in required and qualified personnel (estimated at one third of the USA figure).*

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[1] Manufacturing is used here to denote all sectors of the productive (non-service) industry, including extraction, process and construction industry.

There can be no doubt that in this increasingly competitive world where the operations of manufacturing, services and government are becoming more knowledge intensive, **the winners will be those whose workforces are the best educated and trained at all levels**.

In the European Community the challenges of the integrated market beyond 1992 will be best met by those organisations whose workforces have the highest levels of professional education and vocational skills coupled with entrepreneurial leadership capable of exploiting and managing rapid technological change.

Small wonder, in the face of these trends, that **skills shortages are growing**, particularly in the key generic technologies, electronics and information technology, systems engineering, biotechnology and advanced materials. Further it is obvious that there is a great need to **improve industrial management** - especially in small and medium sized enterprises (SMEs) to create a wider understanding of the necessity to introduce new technology to develop products and production methods - to move from low technology products on shrinking markets to more advanced products on growing markets - and to improve quality as well as productivity.

Obsolescence of Knowledge and Continuing Education and Training

The information revolution, characterized by ever more powerful devices for storing, manipulating and retrieving knowledge, and controlling production processes, is rendering **much previous education and training obsolete**, or simply irrelevant. It is salutary to note that even if useful knowledge has a half-life as long as ten years, intellectual capital is then depreciating at 7%/year (which is a much higher rate than the recruitment of new graduates), with a corresponding reduction in the effectiveness of the workforce.

On these grounds alone it is necessary for industry to develop and adopt systems of continuing education and training to update existing staff : if, as appears likely, the numbers of young people emerging with new knowledge from initial education and training are inadequate despite many Member State Governments (e.g. recently France and Portugal) undertaking to increase numbers in higher education - **the need for** continuing education and training will intensify particularly for **upgrading as well as updating the workforce**.

> *The demographic evolution of European population is such that by 2000 the number of retirements will overtake the new entrants to the labour force. The ageing of the population will also mean that Europe will have to compete with some of the newly industrialised countries like South-Korea and Singapore that will have a much younger work force (the average age in South-Korea is 10 years lower than in Europe) that will be more up-to-date and probably more highly qualified on average.*

Even if some of these challenges can be faced by additional investments in education and training, it must not be overlooked that this will require a formidable increase in the current number of trainers and teachers at all levels, in particular for adult training, as well as an upgrading and updating of the existing trainers.

The Chicken or the Egg ?

A penetrating study in the early 1920s by the Cambridge economist Alfred Marshall entitled "Industry and Trade" placed much emphasis on the role of education. At the time he wrote the greater part of British Industry was still reckoned as the most efficient in Europe; but he foresaw that Germany's system of training and education was likely to give it an increasing advantage in the more technical and scientifically based industries of the future.

With the rapid development of the German economy particularly of the past thirty years or so an increasing number of comparative research studies have been devoted to these issues. In particular the National Institute of Economic and Social Research in London in conjunction with the Technische Universität Berlin has carried out a series of such studies in specific industries which have demonstrated that the higher productivity achieved in Germany is fundamentally due to the general higher levels of skills as a product of the German vocational education and training systems. These studies including the 1986 Study "Relation between education, employment and productivity and their impact on education and labour market policies - a British-German comparison" published by CEDEFOP - the European Centre for the Development of Vocational Training - reinforces IRDAC 's conviction that **the output of education and training systems** (including in particular Higher Education) in terms of both quantity and quality of skills at all levels is **the prime determinant of a country's level of industrial productivity and hence competitiveness**.

The same Alfred Marshall wrote that "Japan ... can hardly fail to become a teacher ere long". And so it has proved : **Japan produces more engineers per head of population than any Western country : Europe overall produces less than half per head**. Additionally participation rates in school until age 18 are at much higher levels than Europe (*95 % of young Japanese are in full-time education up to the age of 18; in Europe this appears to be less than 50 %)* and the percentage of pupils studying mathematics until 18 is extremely high by European standards (for example a 1983 study illustrated the gap by pointing out that 90% of all Japanese pupils do some calculus before they leave school compared with only 15% in the UK !)

Japan has enjoyed **rates of growth of productivity** over decades **many times greater than European rates**. It is just another illustration of the more **optimal use of the human resources** that is being made and which can also be measured in other ways : the participation of the population in the active labour force is much higher than in Europe; the enrollments in higher education are more numerous per head of population, and the stock of researchers approaches that of the European Community (with Japan having less than half the population). These are also areas where Europe is seriously lagging behind the USA.

A 1983 study, "Japan's Intellectual challenge" by Lawrence P. Grayson of the U.S. National Institute of Education describes **Japan's strong commitment to education, particularly engineering education**. It details the massive expansion of scientific and technical education at all levels both to provide the engineers and technicians needed by industry for growth and technical development and to produce the technically literate population required to facilitate the transfer and adoption of technology on which the nation's infrastructure has depended.

> *To illustrate this growth, in the 27 years from 1955 to 1982 the number of bachelors degrees in engineering awarded in Japan rose from 9 600 to 73 600 per annum, the U.S. annual figure being surpassed in 1967. By 1982, on a per capita basis, Japan was graduating 2.3 times as many engineers as the U.S.. Based on figures supplied by the U.S. Department of Labour this report demonstrated a very close correlation between the average annual rates of increase in engineering degrees and subsequent manufacturing productivity growth for both Japan and the U.S. over the years between 1950 to 1982.*

There are of course other factors that affect productivity and economic growth *(consider for instance the fact that the average number of hours worked per year by a Japanese employee is about 2000, compared with the 1600 as average of his European counterpart)* but there can be no doubt that the Japanese strategy (now followed by the South Koreans and others) of substantially increasing the numbers and the quality of engineers and technical staff as a pre-requisite to achieving the planned economic growth, has succeeded. And a **virtuous circle** has been created ! Quoting Grayson :

> *"Educational development and economic growth have been linked reciprocally in Japan. The increased quantity and quality of educated people have provided the manpower necessary for industrial development. In turn, economic growth has enabled the country to afford, and created the necessity for, the great expansion in the number of upper secondary school and college graduates."*

In the skills report (page 25) an example is given of potential shortages of Software Engineers in Japan where the forecast need to year 2000 is to more than double the numbers to 2 145 000 ! The existing numbers employed (let alone the projected increase) are huge by European standards but it is salutary to note that the Japanese electrical industry (largely Electronics and I.T.) grew by 13.3% p.a. between 1977 and 1988.

Understanding skills requirements

The forecasting of skills needs in the European Community and its individual Member States is not well developed and is largely based on past rates of growth and on the perceptions of industrial enterprises (many of which have had low growth rates or even decline in the case of some traditional and mature industries). It is arguable that this largely "bottom up" approach, which fails to take adequate account of new enabling technologies capable of improving competitiveness, will underestimate the demand for and changes needed in technical

manpower. In particular forecasts of the needs of SMEs and the potential growth of the service sector are lacking. The result may well be a vicious circle of restriction of supply and demand compared with the virtuous circle described above where education push and market pull are attuned.

Conclusion

The relationship between education and training and industrial competitiveness is a vital one. It is changing in nature in the face of the pace of technological change and associated global competition. IRDAC is convinced that the education and training issues related to industrial competence and competitiveness have an overriding importance in relation to the future well-being of Europe and its citizens.

Acknowledgements

IRDAC wishes to acknowledge the assistance given by the Secretariat of IRDAC Working Party 11. In particular it would like to express its appreciation for the work of Wouter Van den Berghe of the COMETT Technical Assistance Office for the preparation and finalisation of this report.

Table of Contents

Foreword : European Education and Training, Human Resources and Competitiveness ..... i-v

Table of contents vii

Summary and recommendations ..... I-IV

Section 1 : Introduction 1

1.1. IRDAC Working Party 11 on education and training 1
1.2. IRDAC's approach to the skills shortages issue 3
1.3. What are "skills shortages" ? 3

Section 2 : The European scene 5

2.1. Demographic trends and implications for the labour force 5
2.2. Educational attainment and changes in qualifications and skills 9
2.3. The demand side 10
2.4. New technology and employment 16

Section 3 : Different challenges by sector and country 23

3.1. Examples of sectoral implications 23
3.2. Differences across Europe 30

Section 4 : Conclusions and recommendations 39

4.1. Continuing training for the existing workforce 39
4.2. Adequate skills for the young entrants on the labour market 42
4.3. A European investment in human resources, training tools and technology 44
4.4. Understanding skills requirements 45

Annexes

Annex 1 : List of IRDAC Working Party 11 Members 47
Annex 2 : Terminology and glossary of terms 48
Annex 3 : General references 49

Summary and recommendations

IRDAC, the Industrial Research and Development Advisory Committee of the European Community, established in 1989 a Working Party (WP 11) on education and training issues relevant to industry, in particular those related to the competitiveness of industry[1] across the European Community. IRDAC had recognised that scientific and technological R&D programmes across Europe could not be considered separately from the overall issue of the adequacy of both the numbers and the education and training of highly skilled scientists, engineers and technicians: skills that are needed to carry out innovative scientific research and to apply the fruits of the research to develop European industry's competitiveness in the face of the existing and growing challenges of the rest of the world. The Working Party created in 1990 two specific sub-groups, one on the school-industry interface, and one on skills shortages. This report is the result of the work of the latter sub-group. The report was considered by the full Working Party and then submitted to IRDAC which approved it in its current form in November 1990.

Though IRDAC is an advisory body concerning research and development, it became concerned about skills shortages, since there is evidence now that higher investment in technological R&D - a crucial area in which Europe must keep and improve its competitive position - might not produce the expected economic benefits due to lack of qualified people both to develop and exploit advanced and innovative products and processes. Current and anticipated skills shortages at this level could mean that Europe would not be in a position to harness the outputs of its growing efforts in R&D.

In this report, the skills shortage issue is considered from a European and macro-economic point of view. This does not imply that acute regional or sectoral problems need less attention. It is felt however that there is a risk in focusing on specific areas, whatever their importance, since partial solutions in one field might create problems elsewhere. The purpose of this report was not to make in-depth recommendations for specific countries or sectors, but to suggest ways for overall remedial actions for what in fact is a pan-European challenge by showing enterprises, governments, universities and individuals the more overall framework and needs in which they are evolving.

After an analysis of the skills shortages issues, which highlights the various challenges Europe is facing already, and which will become more acute in the future, the report concludes that if sufficient attention is not given to the skills shortage problem, in particular in areas of technological advance, Europes competitive position will be threatened. The report then makes a series of recommendations which can be summarized as follows :

- ***An overall approach by all actors***

  Current and anticipated skills shortages are such a threat to Europe's competitiveness that immediate action is required from all parties concerned:
  - authorities and administration at Community, national, regional and local level
  - enterprises, both in manufacturing industry and services (including public services), whatever their size or sector
  - the education sector, in particular the higher education and continuing training sector
  - the individuals themselves

  Only an overall and sustained approach by all these actors will lead to adequate responses.

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[1] In this report, "industry" includes all sectors of industry, both services and manufacturing. Manufacturing comprises also production, construction and process industry.

▸ *Investment in upgrading the workforce*

Given the decreasing supply of young people (though on the average better qualified) and the pace of technological change, a massive investment in upgrading of the existing workforce will be needed. This implies :

- a reassessment of educational policies and priorities with increased emphasis on continuing education to become accessible for all
- agreement of social partners on the importance of continuing training for competitiveness of enterprises and hence to be considered as an integral part of companies strategies
- continuing education should become a mainstream activity of the higher education sector: this will need enhanced cooperation with industry
- individuals in all sectors will need to update themselves regularly in a more structured way than before.

It will require a change in attitudes by all.

▸ *Major efforts at stake*

To achieve the above, major efforts are required, including :

- raising the awareness in the general population and with the actors concerned
- organizing better the fragmented continuing education market, including better inventories of training provision and cost-efficient possibilities
- developing more structured and well coordinated forms of continuing education by universities and enterprises, in particular in technology areas where skills problems are acute
- increasing the awareness of the need to improve significantly the management of innovation and technological change in enterprises and stimulating the provision of more flexible modular courses with easier access for busy managers
- increasing the participation rate in the labour force, by attracting more people into employment, particularly including middle-aged women, older people and migrants
- creating new structures in a European context for the education of the large number of additional industrial trainers which will be required for the needed surge in continuing education efforts.

A crucial issue will be the attitudes of industrial managers towards these requirements.

▸ *Adequate skills for the young*

Despite demographic trends, the supply of highly skilled people in Europe must be maintained and even increased, since the young people will still be one of the main carriers of innovation and technology renewal. To guarantee that Europe will have a sufficient stock of young graduates available in the coming decades to deal with the R&D and technology development areas, the following is required :

- more able pupils must be attracted into the mathematical, scientific and technical streams in primary and secondary education.
- able but disadvantaged children across the Community should be supported more to use higher education possibilities
- university curricula should be sufficiently broad and guarantee that graduates have sufficiently flexible attitudes and skills
- no young person should leave the educational system without some basic understanding of science and technology
- nobody in Europe should leave the education and training system unqualified or unskilled

- the human resources stock in lesser developed regions of the Community should be harnessed and used to its full potential
- where appropriate, young people should be retrained towards functions which are more needed by the economy.

Europe can no longer afford not to make optimal use of the talents of its young people.

▸ *Improving educational productivity*

IRDAC calls for improved productivity of education and training, wherever it takes place. Educational productivity has not kept pace with the productivity and complexity growth in the rest of society, notably in enterprises. Therefore the following is necessary :

- a large structural effort in distance and flexible learning is required in Europe
- to a much larger extent, new technology should be used in the production and delivery of training materials
- serious attention must be given to the removal of obstacles such as the lack of standardization, the high unit cost of multimedia training products, the inadequate teaching and learning experience regarding their effective use and the user-friendliness.

The productivity of the economy is dependent on the productivity of education and training. Higher productivity will require better management of education systems.

▸ *The European dimension*

Certain skills issues can only be adequately considered in a European framework, respecting the principle of subsidiarity. Good examples are the efforts under COMETT to promote university-enterprise cooperation in advanced technology areas, or the VLSI design action. More efforts of this type are needed however :

- a coherent European approach with regard to skills shortages should be developed
- the mobility of the highly skilled workforce should be encouraged, in particular in areas where skills shortages are acute
- at the same time, specific actions should be undertaken to avoid brain-drain (in particular from less towards more developed regions) and creating further imbalances in the Community
- all European R&D efforts should be accompanied by related training measures.

▸ *Understanding skills requirements*

IRDAC observes that lack of consistent data and the sheer complexity of the skills shortage issue renders approaches and potential solutions complex and difficult to implement. It calls for a serious standardization effort, and points in particular to the following :

- European and national Authorities should develop consistent and comparable approaches with regard to data collection and forecasting
- there is an urgent need for more and better training needs analysis at regional and sectoral level
- companies, in particular SMEs, should be encouraged and assisted in developing human resources strategies in which training of staff and the forecasting of skills requirements is an integral part.

- ***Investment in education and manpower requirements***

  Finally, it is recommended that thorough studies should be undertaken on the manpower, requirements and related training and skills implications in specific sectors, and on the cost of non-investment in education, so that European policy makers, enterprises and individuals should realise the challenge that is in front of them.

The European Commission is requested to propose a coherent set of actions, through existing and new arrangements and programmes, for the implementation of the recommendations made in this report.

Section 1 : Introduction

1.1. IRDAC Working Party 11 on education and training

IRDAC, the Industrial Research & Development Advisory Committee of the European Community, established in 1989 a Working Party (WP 11) on education and training issues relevant to industry, in particular those related to the competitiveness of industry[1] across the European Community. IRDAC had recognised that European scientific and technological Research and Development programmes could not be considered in isolation from the issue of adequacy of both the numbers and the skills and qualifications of scientists, engineers and technicians : skills that are needed to carry out innovative scientific research and to apply the fruits of the research to develop European industry's competitiveness in the face of the existing and growing challenges of the rest of the world.

There was evidence that higher investment in scientific and technological R & D - a crucial area in which Europe must keep and improve its competitive position - might fail to produce the expected economic benefits due to a lack of qualified people both to develop and exploit advanced and innovative products and processes. This concern of IRDAC, fostered by growing current and anticipated skills shortages, was echoed by DG XII, DG XIII and the TFHR[2] of the Commission of the European Communities who supported the formation and activity of the Working Party. The following terms of reference were agreed by IRDAC and WP 11 following discussion between the Chairman of WP 11 and officials of DG XII, DG XIII and TFHR :

> *"Advise on questions related to the implementation of actions on or affecting European education and training.*
>
> *Specifically, to recommend measures aimed at :*
>
> 1. *Promoting increased industrial awareness, participation and action;*
> 2. *Reinforcing links between university and industry;*
> 3. *Promoting school-industry cooperation;*
> 4. *Encouraging a coherent relationship between activities in the education and training field, and related Community R & D;*
> 5. *Identifying skills shortages and measures to redress them, in particular in priority sectors in relation to Community policies;*
> 6. *Promoting the development and transfer of skills to disadvantaged regions and industrial sectors;*
> 7. *Promoting the development and recognition of continuing education and training on a European basis;*
> 8. *Ensuring the timely dissemination and utilisation of the outputs of actions, including appropriate mechanisms.*
>
> *The Working Party shall operate through a work programme and submit an annual report to IRDAC. It shall work closely with the Commission services concerned (including TFHR, DG XII and DG XIII)."*

The terms of reference were broad, leaving it to the Working Party to decide on its specific work programme and mode of operation.

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[1] In this report, "industry" includes all sectors of industry, both services and manufacturing. Manufacturing comprises also production, construction and process industry.

[2] TFHR stands for "Task Force Human Resources, Education, Training and Youth".

Following two meetings of WP 11 it was clear that there was no lack of important issues needing study. Despite much of the ground having already been trodden (the Working Party noted in particular the report by The Round Table of European Industrialists "Education for Life - A European Strategy"), it was considered that across Europe there was still inadequate realisation by all parties - Industry, Education and Governments - of the massive efforts required in the fields of both initial and continuing education and training to ensure that industry's forward manpower needs could be met.

From these two meetings two inter-related themes were chosen for study and two sub-groups were set up to work in parallel. The two subjects were : "Skills Shortages" and "Schools and Industry".

- ***Skills shortages***

  There was much current evidence that serious skills shortages were already growing at a time of relatively high unemployment; shortages, particularly of scientists, engineers, technologists and technicians were apparent in the key generic technologies : Electronics and Information Technology, Systems Engineering, Telecommunications, Biotechnology and Advanced Materials. In these areas the necessary transfer and diffusion of technology into all sectors of the economy, including mature and traditional industries and agriculture, clearly demands increased numbers of skilled manpower, many with new and multi-disciplinary skills. At the same time there was little evidence that on the one hand, education systems were changing fast enough to match the rapidly changing labour market driven by the accelerating pace of technological change and on the other hand that industry was taking adequate steps to update the skills of the existing workforce through continuing education and training programmes.

  It was apparent that information on future skills needs, and on current and anticipated skills shortages was lacking particularly on a European scale and on a coherent and consistent basis. Skills Shortages was therefore considered a vital area for study and report as was also the second related subject : Schools and Industry.

- ***Schools and Industry***

  There was strong industrial backing for the view that the clear forward need for more scientists, engineers and technicians was unlikely to be met unless across Europe there were more students, (not least females), appropriately educated at compulsory school level in science, mathematics and technology, subsequently to enter studies leading to technical qualifications at all levels. At the present time the attraction to young people of science and engineering, let alone a career in industry, is not adequate to meet the perceived needs of the European Community.

  In the higher education sector in most Member States there was growing and fruitful industrial academic collaboration in many forms, a development as yet generally unmatched at the primary and secondary school level. It was felt therefore that development of such links would be an important area of study.

Both groups have drawn conclusions from their studies and have made both general and specific recommendations for action. These are complex and developing issues and industry, education, government and individuals are all involved. Some recommendations are specifically addressed to the Commission which can act as a catalyst to promote wider action, notably in areas of creating awareness of issues with a European dimension and in initiating European studies and research where adequate information and coordinated data gathering is lacking.

IRDAC above all is convinced that education and training issues related to industrial competence and competitiveness have an overriding importance in relation to the future well-being of Europe and its citizens and merit a thrust and a degree of co-ordination at least equal to that given to the Framework programme for Research and Development.

1.2. IRDAC's approach to the skills shortages issue

This report is the result of the work of the sub-group on skills shortages - but cross-references to the IRDAC report prepared by the other sub-group are made where relevant. The sub-group met 3 times, on 6 February 1990, 25 April 1990 and 13 June 1990. The Commission launched a small study (executed by the MERIT organization in Maastricht) in order to have some background material, which was presented and discussed during the second meeting. Certain parts of this report therefore include results obtained in this study. Other parts result from the research undertaken by the secretariat, contributions from members of the group, and the discussions held during the meeting of the subgroups and within IRDAC. Special attention was given to skills shortages problems relevant to technological developments in industry, though it is recognised that other areas might experience similar problems in the future. The main outcome of this report is a series of recommendations for actions which reflect the discussions held. Though the report does not claim to be a full scientific study, it includes sufficient background data and figures to underpin the statements and analyses made; it is only a partial approach to what is a much more complex problem.

In its report, IRDAC considers the skills shortage issue from a European and macro-economic point of view. This does not imply that acute regional or sectoral problems need less attention. It is felt however that there is a risk in focusing on specific areas, whatever their importance, since partial solutions in one field might create problems elsewhere. Specific problems need ad hoc solutions depending on the particular circumstances, though there is a danger that, by a mere consideration of a partial problem, one loses the overall context. In addition, the purpose of this report was not to make in-depth recommendations for specific countries or sectors, but to suggest ways for overall remedial actions for what in fact is a pan-European challenge by showing enterprises, governments, universities and individuals the more global framework and needs in which they are evolving.

The report has been submitted to a plenary session of Working Party 11 on 13 September 1990. It was then submitted in its finalised form to IRDAC which approved the report in its current form in November 1990.

1.3. What are skills shortages ?

Though definitions of "skills shortages" vary, in general they refer to a labour market problem where the available (and/or anticipated) stock of people with certain "qualifications", "skills", "professional experience" is not meeting the current or anticipated demand. The "skills market" can be seen as a group of different (but interactive) segments of the labour market, each trading its own set of occupational categories. In practice, the notion "skills shortages" is often used to stress underlying labour market problems which result from shortages in the qualifications and experience of employees, due to insufficient training and education.

Several interrelated factors contribute to skills shortages :

- With regard to the existing workforce, there can be a mismatch between the available stock of skills and qualifications and the numbers required by the economy (e.g. lack of construction engineers but surplus of architects, enough electronic technicians but insufficient VLSI designers,

sufficient materials specialists but not enough appliers, sufficient programmers but few with knowledge of recent tools, unemployed teachers but lack of teachers in mathematics, etc.). This can be a short-term or a longer, structural problem.

- The existing skills are often under- or badly used for a variety of reasons : in fact, many people are employed below and outside their full capabilities (e.g. engineers involved in technician activities; lawyers in administrative functions below their qualifications; mathematicians in bookkeeping positions; PhD-holders without an advanced job).
- The changing demands caused by rapid development and changes in the economy require adaptations in skills which often do not take place (e.g. the introduction of automation in manufacturing plants requires retraining of all the workforce concerned; software specialists need to understand the operation of a chemical plant for which they design the control process software).
- The supply of new people on the market does not meet the demand for new or existing jobs, either in terms of quantity or in terms of type of qualifications.

Many of these aspects, which mutually reinforce each other, are known to have existed for a long time (even in periods of serious unemployment); however, the increasing pace of technological change and the current demographic trends in Europe have made the problems much more acute.

Skills shortages raise problems with many facets. To simplify matters, one could make a distinction between quantitative and qualitative issues. The quantitative aspects of the problem have to do with the incapacity of the existing education and training systems to produce and update sufficient numbers of people with the desired qualifications. The qualitative aspects relate more specifically to the content and type of qualifications (formal or informal), in cases where, for a given sector or profession, the education and training structures cannot cope with the new types of demand. The qualitative problem is also related to the underuse of existing skills or skills problems in one sector that result from pressures and shifts elsewhere. In many areas, both quality and quantity problems are known to exist. This is particularly the case in advanced R&D and technology areas, where the requirements are changing and increasing at a growing pace, without finding an adequate and coordinated response.

Some skills shortage problems are purely local or regional in nature, while other have a pan-European and even wider dimension, although their importance can vary strongly from region to region. Skills shortages that are felt across Europe are macro-economic problems implied by the inadequate adaptation of educational provision to a changing economic environment. Solutions require careful long-term thinking and measures, as well as a better insight into future developments and a flexible attitude to their requirements. Advances in R&D and their technical exploitation are typical examples of such areas. Purely local or regional problems on the other hand have often to do with short term economic developments. The actors concerned might have been late in discovering the problems. However, once these have been identified, often geographical solutions can be found, provided the parties concerned show the required flexibility.

In summary, skills shortages to a certain extent have always existed, since at no point in recent history has there been an exact match between the demand of the economy and the output of the education system. However, because of the current changing economic and industrial environment the problems threaten to assume much more significant proportions, essentially for the following reasons :

- demographic trends in Europe which could put at risk the supply of sufficient numbers of qualified people, even if participation rates continue to rise;
- the advances in R&D and technology, which impact on work organization and functions of most organizations, and therefore require more highly skilled people with a varied range of new qualifications;
- the growing requirements of the users who want better, cheaper and more customized products and services, at lower cost and in a shorter time span;
- the achievement of the Internal Market, alongside a more global trend of internationalization, which will open a number of opportunities, but will also lead to additional requirements.

Section 2 : The European scene

2.1. Demographic trends and implications for the labour force

The supply side of the labour and skills market is largely determined by the potential labour force, which in turn is dependent on the demographic situation and its evolution. For that reason, this report first examines some demographic trends as well as their implications on the structure of the labour force. In this section, the European Community is considered as a whole. However, there are significant differences across Member States, some of which will be highlighted in the examples throughout this report.

The demographic developments in EUR-12[1], as analyzed and forecasted by the European Commission, are shown in Figure 1. It shows the evolution and forecasts for the period 1965 - 2025 of the absolute

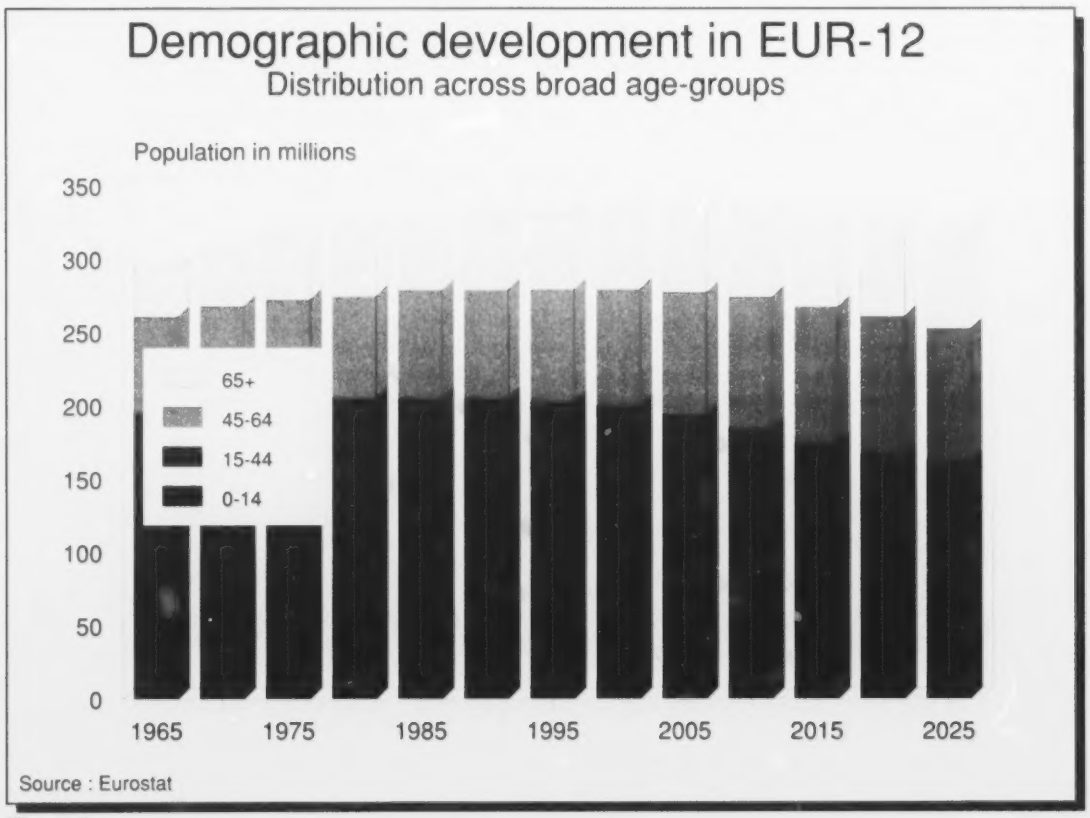

Figure 1

numbers of inhabitants for four age groups : 0-14 years, 15-44 years, 45-64 years and over 65 years. The age group 15-65 is normally considered as equivalent to the potential labour force (though the

[1] EUR-12 will be used to refer to the 12 countries of the European Community. For practical reasons, the former GDR could not be included in figures for Germany or the European Community.

active labour force is smaller), with the people in the other age groups depending on it. Therefore, Figure 2, which is derived from it shows the "dependency rates" of the age groups 0-14 and +65 as a percentage of the 15-64 age group.

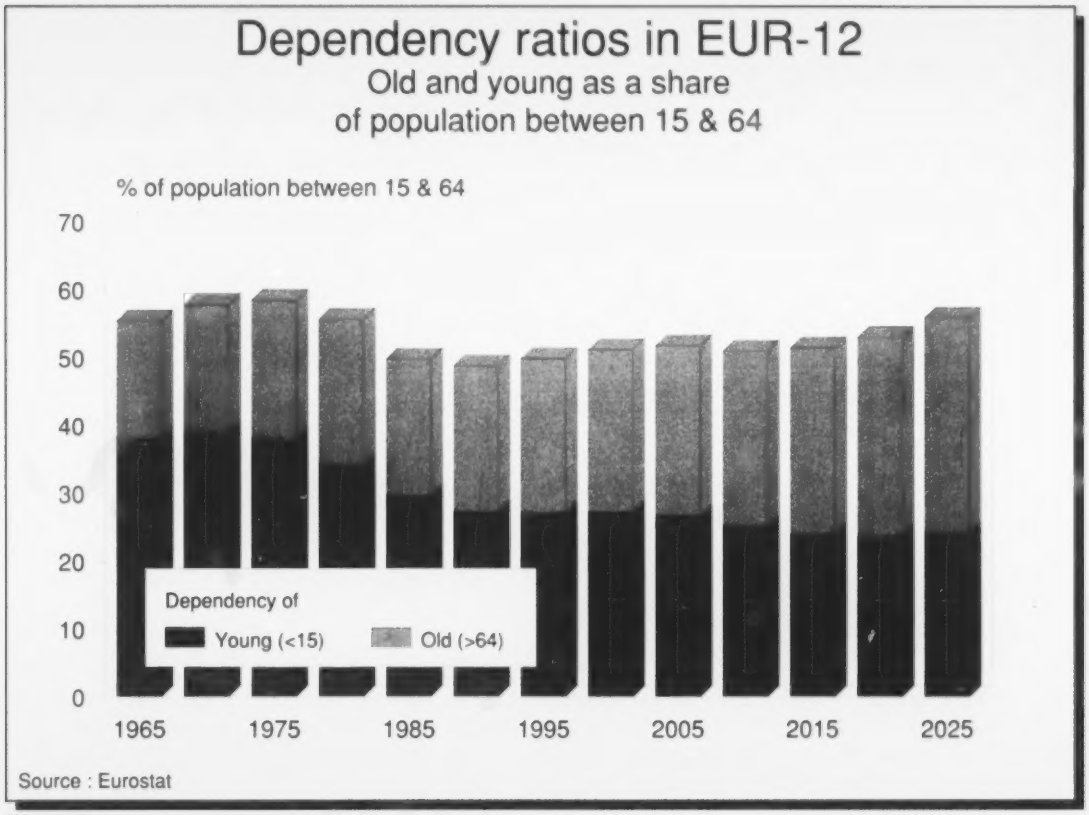

Figure 2

The important observations for the skills context are :

- the total number of young persons increased considerably in the period 1975-1985, but is now in serious decline;
- there will be a slight rise in the total population of EUR-12 up to the year 2000, followed by a gradual decline; this will be accompanied by a considerable ageing of the population and increase in the "old dependency" ratio and a steeper decline of the potential labour force (age-group 15-64).

With regard to the implications and constraints of such demographic developments on the potential evolution of the labour force as a whole, a number of analyses are available. Figure 3 shows the evolution of the labour force, assuming constant participation rates. From these and other data it can be concluded that :

> **if participation rates were to stay at the 1985 level, then the total labour force rises slightly up to the year 2000 and then falls at an increasing rate, accompanied by a considerable ageing of the labour force; a more realistic scenario which assumes a growth in the participation rate indicates an increase of the active labour force during 1990-2000 of 4 to 5 per cent in total, but nevertheless a decrease in the early 21st century.**

Such a conclusion is of course partly speculative, since it is unclear to what extent participation rates could change. The participation rate is determined by :

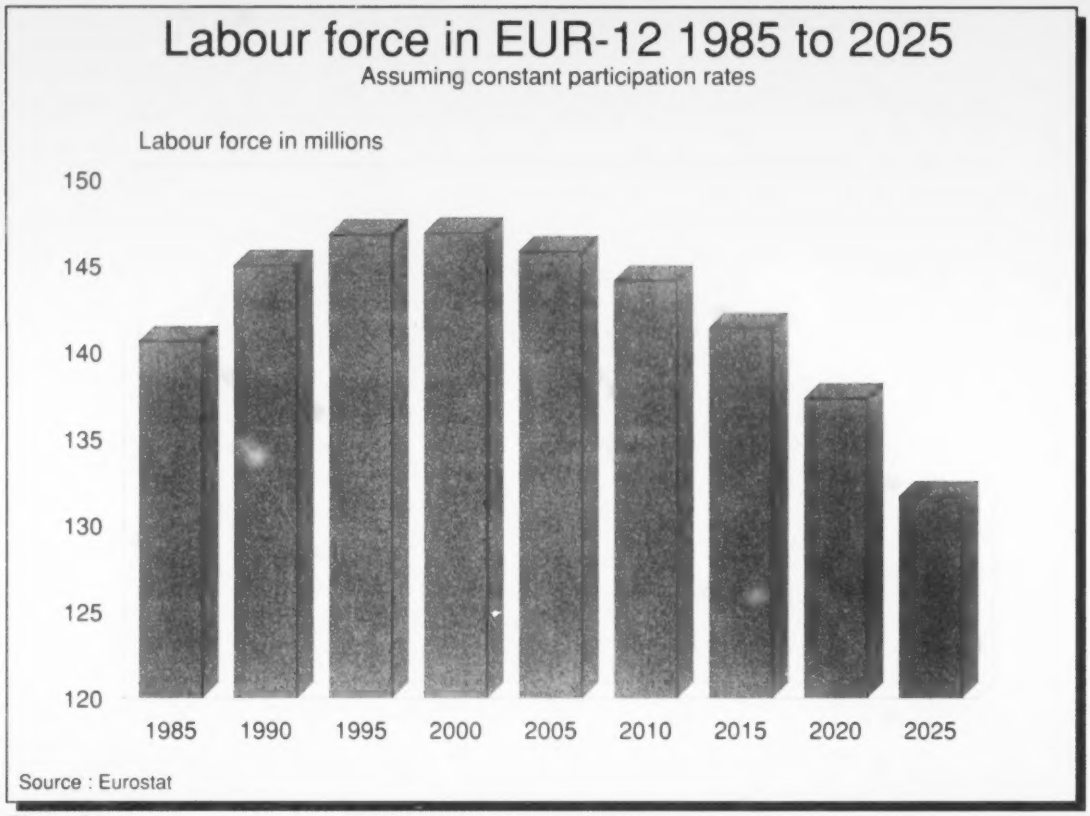

Figure 3

- measures taken to encourage the participation of males and females (the participation of males engaged in economic activity has fallen, mainly because of earlier retirements, while that of females has risen over the past 2 decades);
- immigration and emigration (in EUR-12 since 1975 migration has had little effect on overall labour force changes - but with increased mobility within the Community and the developments in Eastern and Central Europe, this could change).

Note also that currently in the USA and Japan, the potential labour force represents 2/3 of the population, as in Europe. However, participation rates are already higher, as displayed in the following table. Male and female participation are higher outside EUR-12, in the USA in particular the female participation, and in Japan particularly because of the higher male participation rate.

% participation in labour force %[4] (1988)			
	Men	**Women**	**Total**
EUR-12	80.86	53.10	66.98
USA	85.50	66.90	76.10
JAPAN	87.10	58.40	72.70

[4] Participation rate is defined as the labour force divided by the population of working age (15-64)

These figures could indicate that - at least in certain parts of Europe, since the rates are not uniform across regions - it would be easier to adapt to a higher quantitative demand, since a decrease in the potential labour force can be compensated by an increase in the participation rates.

The above relates to the general employment picture. For the younger part of the labour force, which is still the most important group of new entrants to the labour market and which is a major source of innovation, the outlook is bleak. If one considers the active labour force in the age group 20-30, a forecast of a continuing annual reduction of 1.7 % is made for EUR-12 and of 1.3 % per annum for the USA. Japan is expected to have an annual rise of 0.75 % per annum until 2000, and thereafter to have similar decreases because of the ageing population. All three economic areas will face much larger numbers of retirements after 2000, which will then exceed the supply of new people. Another factor which is often neglected is that increased educational attainment of the young has a negative quantitative effect on the labour market. In fact, the measures taken in most countries to increase educational attainment (in particular by increasing the participation in higher education) have a negative effect on labour force participation rates, since the potential pool for the labour market diminishes (unless the average retirement age is altered as well).

Even if the forecasts mentioned should be used with caution, they indicate that the starting base for the next decades is far from excellent. If no corrective action is taken, there is a major risk that Europe will lose some of its competitive strength because of a lack of sufficient qualified manpower. And while the above might indicate that Europe's position is not dramatically different from that of its major competitors (with Japan to expect similar problems in 10-15 years time), one should realise that certain other countries, in particular in the Far East are developing fast, and have a much better demographic pyramid. It is illustrated in the following table by developments in the median age of the population as a whole in a few selected countries.

Median age in selected industrial countries

	1980	1990	2000	2010	2020	Increase in years for 1990-2020
F.R.Germany	36.7	38.5	41.1	44.8	46.7	8.2
UK	34.6	35.9	37.7	40.3	40.9	5.0
France	32.5	34.7	37.3	39.7	41.1	6.4
Spain	30.3	32.1	34.2	36.5	38.5	6.4
USA	30.0	32.8	35.6	36.9	37.4	4.6
Japan	32.6	36.8	38.7	40.0	41.7	4.9
S. Korea	21.8	25.5	28.9	32.1	35.0	9.5
Brazil	20.5	22.7	24.7	27.3	30.0	7.3
India	20.6	22.6	25.4	28.9	32.3	9.7

The table shows that the difference between, say, the Federal Republic of Germany and South Korea is striking. The median age is of course highly correlated with the median age in the active labour force, which means that some of these developing countries will be in a position to compete with Europe with a much younger, cheaper and more up-to-date work force.

2.2. Educational attainment and changes in qualifications and skills

To what extent have these developments been accompanied by shifts in the qualifications, degrees and skills of the people and what can we conclude from what is occurring ? In fact, the educational attainment of the labour force, acquired in formal ways (e.g. classic educational system) or more informal routes (professional experience, continuing training, self-learning) are important indicators of the potential for economic growth. In turn, the distribution of this attainment influences the distribution of the well-being derived from this growth.

It is well known that since the Second World War Europe (and even more dramatically Japan) witnessed a rise in the educational attainment of its population. It is beyond the scope of this report to present an analysis of these trends. It is well illustrated by the "boom" in higher education enrolment, at a moment of slow population growth (see Figure 4). Between 1960 and 1970 most

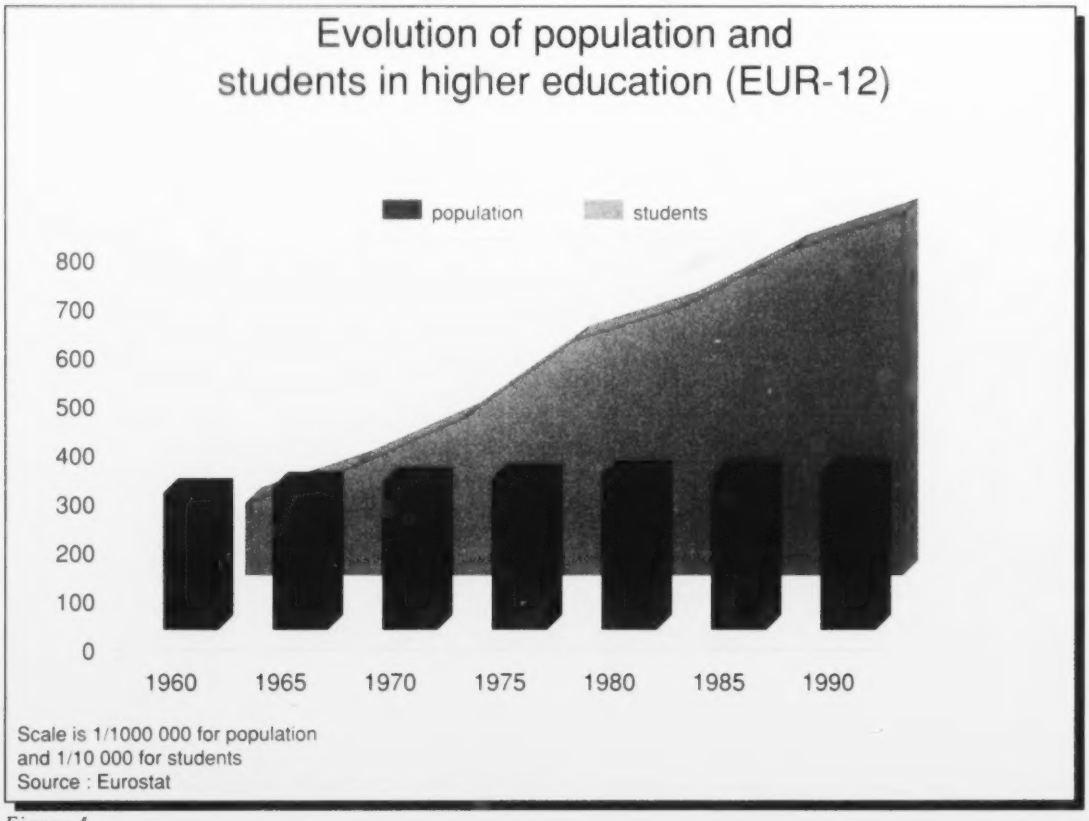

Figure 4

European countries almost doubled their number of higher education students; since then the growth has been somewhat slower. There are however significant differences across European countries (as is the case within the USA, in particular in relation to minority groups). Several governments in Europe (e.g. France, the U.K. and Portugal) have announced recently that they want to increase significantly the number of participants in higher education, despite demographic trends.

In fact, in the very recent past, participation in higher education appears to have increased, which is a very positive development. Some words of caution are however necessary :

- most of the growth in recent years is due to increased female participation (which in many

countries is now at the same level as males);
- part of the increase is in areas where the economic and industrial relevance is difficult to measure and could therefore lead to further mismatches on the labour market; in particular, there has been a relative decline in the participation in exact science and engineering areas, which are the crucial disciplines for advanced R&D and the development of wealth creation;
- students from families with manual backgrounds or minority populations are still under-represented in higher education.

International comparisons are difficult, but is well known that Japan's educational attainment is now higher than in Europe[5], while the USA situation seems to be worsening[6]. The important point to note is that the reasons for these differences lie with the emphasis given to quality and standards in primary and secondary education, rather than differences in higher education systems and practices.

The rise in educational attainment is also dependent on various aspects of informal training : self-learning, continuing higher education and training, professional experience. Little comparable data exists on these topics, but it appears that the changes here have been less spectacular than in formal education. In a period of structural change, demand for technological updating, coupled with fewer young people on the market, it is questionable whether current ill coordinated practices are adequate, and whether more structured support for continuing education should be developed. A handicap to that is that in most Member States, continuing education and training is widely dispersed and dealt with partially in many different Ministries : Education, Employment, Economy, Labour, R&D, etc.

There is another area to which little attention has been given so far : the educational environment outside school and work. The social and cultural changes related to changes in family patterns (with their direct impact on individuals' education) and the reduction in working hours[7] have increased considerably the individual's time available for hobbies, culture, self-education and personal development. This provides a challenge which has not yet been fully grasped : the provision of new educational opportunities to stimulate and match the potential demands from this new, individually driven market place. Information and telecommunication technologies have the potential to meet the requirement for readily available attractive, user-friendly and cheap educational packages and the development of such a market could prove to be a very efficient and cost-effective way of upgrading the skills and qualifications of individuals.

2.3. The demand side

The changes in the demand for skills are essentially of two different natures :

(1) The requirement for higher numbers of people with specific qualifications. This can apply to both the whole economy and to individual sectors. Such demand may be more acute in one sector than in another. In addition, the increased demand for certain staff with particular skills may be compensated by a diminished demand for staff with other skills (or lack of skills).

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[5] For instance, more than 95 % of young Japanese are in full-time education up to the age of 18. The situation in countries like South Korea seems to be very similar. On the contrary, in the European Community exact figures are not known, but are, for full-time education estimated to be below 50 % (e.g. 32 % for the UK). The IRDAC report on schools and industry contains further figures on related topics.

[6] Recent reports warn against a reducing of educational level with many high school leavers, and related low standards amongst graduates of colleges.

[7] In Germany, the average number of average hours actually worked per person per year decreased from over 2300 in 1950 to 1623 in 1988; for France, the decrease was less spectacular but still significant : from 1989 to 1547 hours. However, in Japan, the decrease was only from 2289 to 2078 hours.

(2) The requirement for other types of people with different, flexible and multidisciplinary qualifications and skills which better match changing professional and occupational patterns.

The first aspect will be discussed under this heading, with section 2.4 covering some aspects of the more complex second item.

The general demand for labour is determined by the growth of the economy (expressed in the growth of the GDP) and the labour productivity growth. Both are partly but increasingly dependent on technological development. From the difference between economy growth and labour productivity one can derive a rough indicator of the growth or decrease in the employment of the labour force. Some OECD figures and forecasts are shown in the next table.

Annual employment growth		
	80's	90's (forecast)
EUR-12	0.7 %	0.6 %
USA	1.6 %	1.3 %
Japan	1.2 %	1.5 %

As can be observed, the current and expected growth rates are slower than with our major competitors. Of course, the forecasts are only valid on certain assumptions, including the hypothesis that the supply system would not put constraints on the growth. Also, such econometric forecasts are based on projections of market demand. However, in recent years it has become obvious that there is also a technology push of the market, and that the level and range of skills available can change market demand. The Japanese market explosion is a case in point.

> *To illustrate the importance of skills and technology push for employment growth, consider the situation of the shipbuilding industry, where the reverse has happened. Currently, there is little employment and skills demand in this sector in Europe, since the shipbuilding industry in Europe has been scaled down. But this decline found its origin in an inadequate adaptation to new technological challenges. What really went wrong was the technology organization at management level which failed to reorganize production in view of the new opportunities. Hence, the required technology and skills update did not take place, and many European companies were chased out of the market. A better technology and skills based workforce could have avoided this phenomenon, and would now have been a source of employment growth.*

Overall comparisons with the general forecasts on the supply side (the match between "supply and demand") then show that for the labour force as a whole, Europe, the USA and Japan will show similar patterns, with a labour market which becomes tighter by 2000 (provided the economic growth continues). This is a statement which applies for the labour force as a whole. The situation is however much different if one looks at specific age groups and specific occupations. In relation to the supply and demand of young people, it appears that Japan, with its relatively young population, is still better armed than Europe and the USA. As said earlier, countries like Singapore and South Korea are in an even more comfortable position. This situation is especially threatening since it is the young entrants to the labour market who in general have the up-to-date skills and ideas that are required for innovation. It means also that the pool of potential young researchers and engineers, crucial in the generation and application of advances in R&D, could well be too small, if no appropriate measures are taken.

Maybe the best indicator that today we are facing structural problems is the current employment market with high demand occurring at a time of still significant unemployment rate. This might be illustrated by Figure 5[8]. It shows that, in the early seventies there was a high demand and low

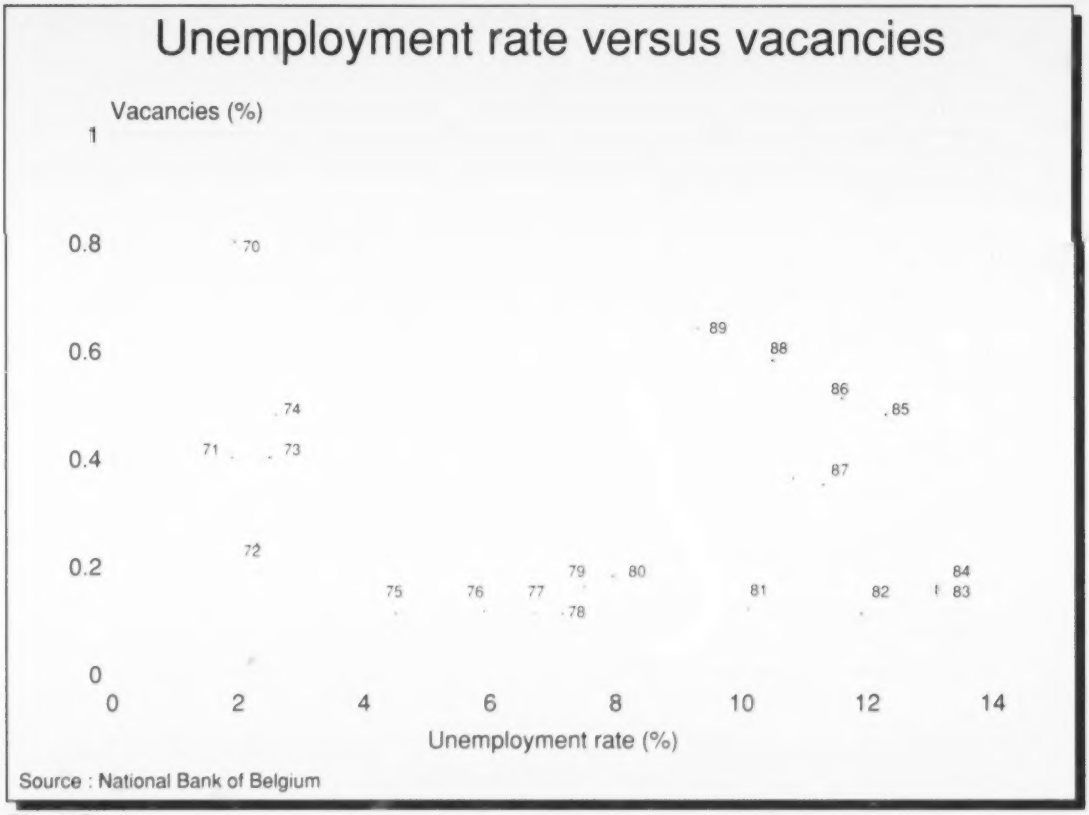

Figure 5

unemployment; in the late seventies and early eighties, there was a low demand and high unemployment. Today however, we are faced with mismatches characterised by both relatively high demand for jobs, as well as unemployment.

Another, partly hidden, structural mismatch is the problem of hidden unemployment, with many people either working below their potential level (for example engineers doing the work of technicians, economists doing bookkeeping), or sometimes in occupations for which they had not obtained the right qualifications (e.g. teachers in secretarial posts). The latter may not be a problem "per se", but it raises the question of the effective use of resources put into educational systems. If people work below their potential level, they are often an obstacle for lower skilled or less gifted people to obtain employment. It follows as well that inadequate skills at lower levels, e.g. lack of good technician training, often demand that higher skilled people execute these jobs. This is an example of a bad response to the introduction of new technologies, since it provokes underutilisation of resources. Finally, good employment in one sector or profession, might be the cause for skills shortages in another one (e.g. financial and other services attracting engineers, and therefore exacerbating problems in manufacturing industry).

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[8] The figure holds for Belgium, but similar trends have been observed across Europe.

Current and anticipated skills shortages in specific sectors or for specific professions are much more difficult to measure. In Section 3 examples will be given of current and anticipated requirements and trends in a number of sectors. With regard to overall needs and expected developments in skills levels and the need for certain professions, no European-wide comparisons are available, because of lack of data. However, numerous studies all point in the same direction, as described below.

- First of all, there will be a need for a very significant reduction of unskilled workers and a much more highly skilled labour force. Some current forecasts include :

  - *In Danish industry, the demand for unskilled workers is expected to fall from 35 % in 1980 to 10 % in 2000; technicians would (need to) increase from 10 to 30 %, and management and professional staff (say, university graduates) would need to double from 15 to 30 %.*

  - *Projections for (West-)Germany indicate a demand for a reduction between 1982 and 2000 of more than 3 million unskilled people, to be compensated by 1.6 million additional higher education graduates and 1.3 million skilled workers. It is yet unclear to what extent the German unification could modify this projection.*

  - *For the UK, projections for the period 1988-2000 expect a 30 % increase in employment for "managers and administrators", around 20 % for professional occupations, and more than 15 % in personal and protective services. Other groups feature less, with plant and machine operators showing an 8 % decrease (which is lower than in the other examples).*

  - *Forecasts for the Netherlands indicate that between 1985 and 2000 the demand for people with at least upper-secondary education would change from 58 % to 69 % of the labour force; unskilled or low skilled people (approximately primary education level or slightly above) would be in excess supply, and therefore subject to serious unemployment problems, at a moment of growing skills shortages for higher education graduates, in particular in technical areas.*

  - *In France, occupational forecasts for the period 1982-2000 show that the educational background of every occupational group will change in favour of higher educational qualifications (e.g. the proportion of BAC+2 or higher should increase from 11 to 21 %), irrespective of whether the group is likely to contract or expand numerically over the rest of the century.*

  - *Projections for Portugal for the period 1983-2005 show a decreased demand for unqualified staff from 15% to 10%, a similar decrease for low skilled people and of course a similar increase for highly skilled people. These changes appear less spectacular than in some of the more developed countries.*

  - *A more formalised approach is given in Figure 6 (next page), which holds for the USA, but is equally relevant for Europe. It shows the distribution of jobs according to a skills rate which has been given to each job (e.g. transport workers = 2.2, marketing & sales = 3.4, natural scientists = 5.7). The figure compares current and future (± year 2000) distributions, and the clear shift towards higher skilled jobs is evident.*

  The anticipated increase in required qualification level is in line with current trends of growing educational attainment. However, it is far from evident that both trends will match adequately. Firstly, market forces do not have as much impact on young peoples educational choices as might be desired. Secondly, the higher attainment has to be obtained covering the right mix of disciplines and qualifications among the young.

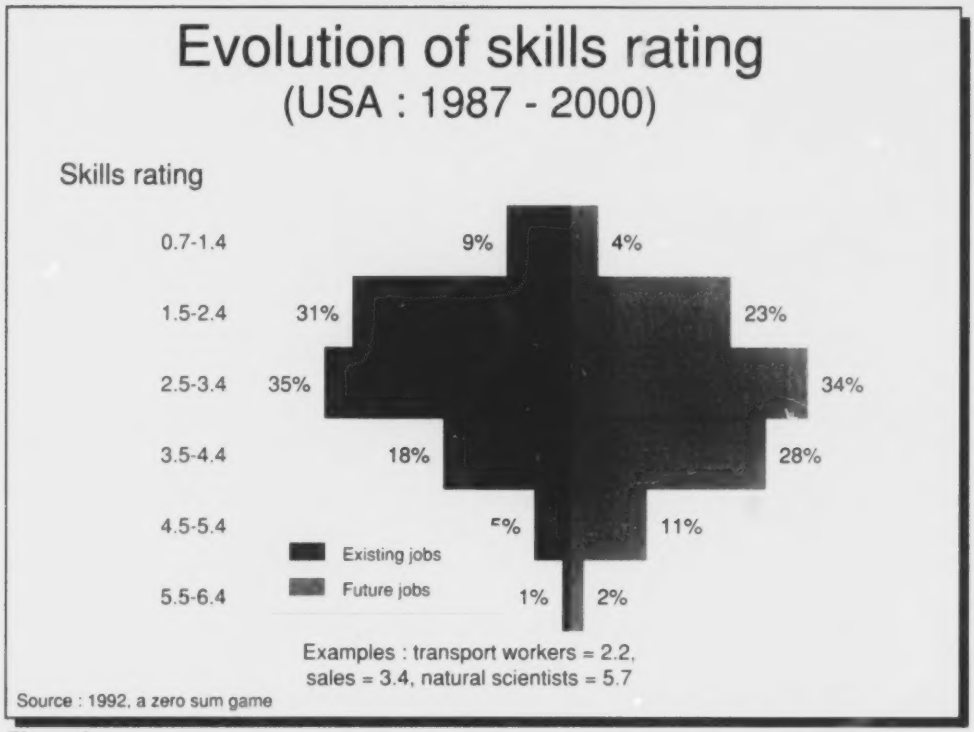

Figure 6

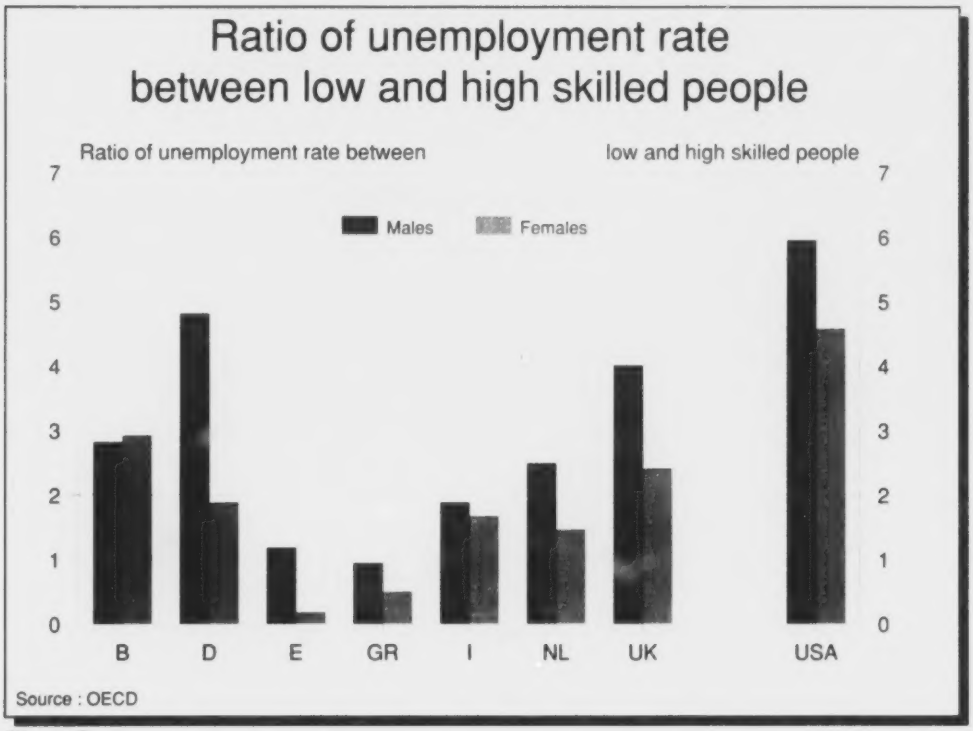

Figure 7

Though it is well-known, it is relevant to recall the strong negative correlation between educational attainment and unemployment. In Figure 7 (previous page) the unemployment rates are compared of low skilled people (in this case people not having completed secondary education) and highly skilled people (in this case people with a university degree). The ratio between the rates shows the big advantages of the higher skilled people on the labour market, even if one knows that some types of university graduates face more problems than others. The figure also shows that in certain countries, females' educational attainment is less a guarantee for employment than for males (partly because they have different qualifications which are currently in less demand by the economy). With increased commitment of all governments to raise the qualifications of young people leaving schools, there are probably good prospects here that youth unemployment may decline. However, a much bigger problem exists for the "older" unskilled workforce which is unemployed. Heavy investment in retraining will be needed to bring these people back into the active labour force. Unemployment will become therefore increasingly a problem of the remaining, older and lower skilled work force.

- A second major market demand phenomenon to which existing studies point is the growing importance of services compared to the manufacturing sector. Services are already the largest employer in the USA, and are becoming so in all the Member States. This has several implications, but in the context of this report the following aspects should be highlighted[9] :

  - currently, the service sector as a whole is labour intensive (and source of employment creation) but has low productivity growth (compared to manufacturing), mainly because of the low technological usage and a below average skill level of its employees;

  - some parts of the service sector (e.g. banks) are employing a much higher number of highly skilled people than before; this implies shifts in employment patterns of many university graduates (i.e. engineers) and hence less correlation between basic education and future employment;

  - the introduction of information and communication technology in offices requires a complete change of daily operational modes of many service sectors, and hence of its skills requirements; the overriding theme appears to be one of a move away from specialisation according to Tayloristic principles, towards horizontal, functional jobs where the same person is required to handle a whole range of jobs which were hitherto executed by several employees.

  For Europe to remain competitive, it will need an efficient and productive service industry. This will lead to the requirement of somewhat less labour intensive, more productive and more technology-based services.

- The latter element brings us to the third important observation concerning the future demand, on which we will return later in this report: technology is changing the nature of the qualification and skills demand. This applies both to job content (in particular the advanced jobs in R&D, engineering, design) and the way tasks are handled (essentially because of growing computerization and automation of a range of tasks) and their impact on work organization, logistics and management.

- The final observation regarding market demand for labour is of a more general nature. In fact, market demand and educational demand are not just parallel processes, but feed back into each other, so that one could speak of a educational supply push of the employment and skills market. Higher education attainment allows industry to advance, which then leads to even higher

[9] Some of these phenomenon are also relevant to certain parts of manufacturing industry.

qualifications, which in turn contribute even more to higher productivity etcetera. The phenomenon is illustrated by Figure 8 (and has been developed to some extent in the Foreword of this report):

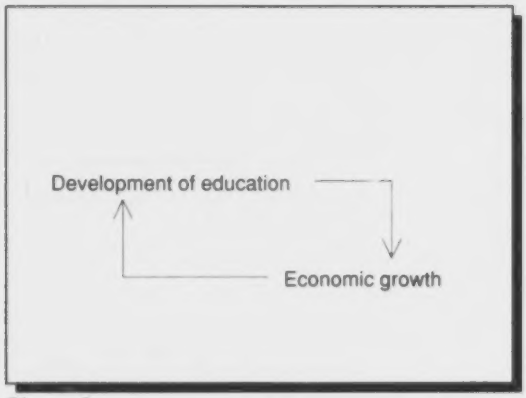

Figure 8

In summary then, the demand for labour, skills and qualifications is changing and it appears that supply trends can cope with the quantitative needs for another decade. However, already today, skills shortages in certain occupations are hampering growth possibilities and could undermine Europe's competitive position. This does not seem to be a very comfortable starting position for entering the 21st century. In addition, if no appropriate measures are taken, the situation after 2000 is forecast to be much more bleak, not only because of a decreasing output of the educational system (though on the average higher qualified), but even more because of an increasing number of retirements, which will overtake the new entrants to the labour force, as well as mismatches between education provision and employment patterns.

2.4. New technology and employment

The current and sustained wave of rapid technological change is probably without historical precedent[10]. The impact of technological advance is felt in all aspects of society, and notably on employment patterns. In fact, advances in R&D and technological change affect employment in a number of ways :

- they change the content of a whole range of jobs (in particular those concerned with R&D, engineering, design, control);
- they change the way jobs are done, their interaction and organization (requiring more multidisciplinary skills and other management models);
- they increase the productivity of the jobs (by reducing labour intensity for the same range of jobs, or by increasing the output for the same number of people).

[10] Of course, the invention of the steam engine, the introduction of electricity and later the combustion engine had also major impacts, but occurred in economies which were much different from now.

On the latter, there has been the debate on whether the introduction of new technology will increase or decrease the number of jobs. IRDAC observes that at the micro-level of the individual company, the introduction of new technologies is sometimes accompanied by job losses, mostly because the pace of the change is too high to be coped with adequately by an enterprise. However, IRDAC believes that at the macro-economic level the adequate use of new technology leads to higher productivity, greater wealth and hence job creation, rather than job losses, though in general the new employment is of a different nature and a higher level than the jobs it replaces in other sectors of the economy.

> *A comparison of the turnover, productivity and employment trends in "innovative" and "non-innovative" firms in the Federal Republic of Germany, showed that in the period between 1979 and 1985 - a period with considerable unemployment rates - innovative firms achieved much higher turnover and productivity growth than non-innovative ones. While both groups experienced falls in employment, the fall was much greater in non-innovative firms.*

Therefore technological advances do have a significant impact on the skills and qualifications required by the economy. The need for a higher skilled workforce is inevitable, across all sectors and occupational groups, though it is recognised that at micro-level there are cases where the introduction of new technology made current skills obsolete and superfluous. The average skill attainment needs to increase; IRDAC welcomes the fact that many countries in the European Community have realised this and are taking steps in the right direction. However, it is unclear whether, given the pace of technological development, current and anticipated measures will be sufficient to provide Europe with the required much larger group of people which can use, exploit and manage the complexity and the opportunities of new technology and its applications. This means essentially an increased demand for

- technically educated people, in particular engineers and higher technicians, as well as natural scientists and skilled technicians;

- people who understand technology and its potential, and who develop attitudes to work in a changing work environment (this group is much larger than the previous one).

Already now these people are in high demand. The remainder of this section will discuss both groups.

To start with the "technologists", one should first of all realize that many of the current "structural vacancies" (as can be observed from data like in Figure 5), are to a large extent to be sought in pure "technical" occupations, in particular (but not exclusively) in specialised areas such as software engineering, systems analysis, manufacturing processes, etc. Though engineers, technicians and scientists are not the only professional categories concerned, there are a number of worrying aspects:

(1) the growth of demand is much higher for technical professions than for the labour market in general;

(2) the supply of new entrants in technical professions is lower than average;

(3) it is generally much more difficult to replace technical by non-technical staff than vice versa, since the aptitude towards scientific and engineering tasks requires a long and solid educational preparation.

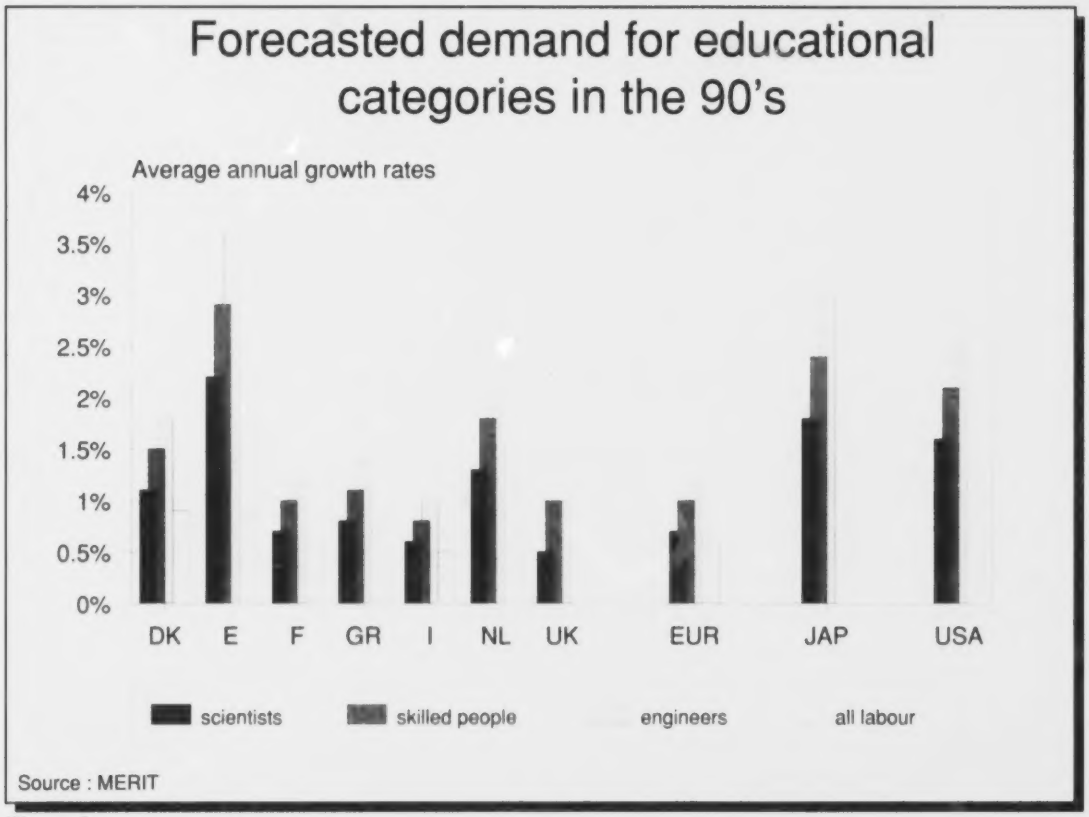

Figure 9

- With regard to the first point, Figure 9 shows a forecast with regard to the general labour demand in the 90's, and the specific demand for engineers, scientists and "skilled labour" (in this case higher education graduates). It underlines the strong overall demand for engineers (growth rate 1.2 % compared to 0.6 % on average)[11]. This thesis is supported by more or less every study on the subject, though there are notable variations in the scale and the nature of the demand, depending on regional or sectoral circumstances. Note also that the unemployment rates for engineers and higher technicians are currently very low.

  Major companies recruit every year higher numbers of engineers and scientists. For instance, in Siemens, in 1960 engineers and scientists constituted 8.6 % of the workforce; in 1987 it was already 18.5 % and it continues to rise.

  In Belgium, a recent inquiry of the employers' federation among its members showed acute shortages of engineers and technicians in most sectors, and called for structural changes in education and training to cope with the demand.

- With regard to the second point (insufficient supply), it is often overlooked that the boom in university enrolment in the sixties and seventies did not witness a proportionate increase in technology related disciplines : in fact, in most countries, the share of engineering among higher

[11] Note also that the anticipated demand in Europe is lower than in Japan and the USA, because of a lower forecasted growth rate, which shows the problem is a "chicken or egg" situation.

education courses has dropped by half over 20 years[12]. Reasons for this trend are manifold, but have to do with factors like insufficient female participation (still below 20 % and now stabilizing), the demanding nature of engineering studies, the required mathematical background of students, and some and perhaps growing anti-scientific and anti-industrial attitudes amongst young people[13].

To put the current trends in a wider perspective, engineers now constitute about 1.5 % of the labour force in Europe and the USA, but 2.5 % in Japan. Recent graduation figures indicate growth rates in Europe, the USA and Japan of the order of 5 % per annum, which mean that the relative positions have stabilized. To put these data in another way, in 1960 the stock of Japanese engineers was about equal to that of the UK; now it is about 4 times as big.

- Thirdly, the difficulty to replace technical by non-technical staff is an assumption which could be challenged, but it appears that many engineers in the course of their career change towards non-technical occupations such as management and commerce, but on the other hand, there is a low in-flow into specific engineering functions such as design, applied research, development and project management. Similar arguments apply to the technician level where vacancies seldom can be filled by people with no technical education.

Thus, it is obvious that the demand for technologically educated people is high and trends are worrying. Why then do we need these increased cohorts of young people with such skills ? Essentially, they are required in two capacities :

- Innovators : to do research on and/or introduce, develop and adapt new technologies and applications. This holds for scientists, in particular in the application of exact sciences, and to a lesser extent for engineers. Lack of well educated people in developing technology areas will hamper the possibilities for technological development. The numbers involved are relatively small, but they are a key group for Europe. The current perception is that universities are not sufficiently equipped (often due to lack of financial resources or collaborative agreements with industry) to deliver sufficient numbers of such people in certain specialised fields (in particular high tech areas such as microelectronics, biotechnology, chemical processes, new materials, aeronautics, etc.).

  As an example, an inquiry in France amongst 1800 selected technology advanced companies, showed that 70% mention severe difficulties in recruiting experienced staff for R&D activities (though for recruiting young inexperienced researchers only 30 % of the companies are in trouble). Main problem areas are mechanics, electronics, information technology, and to a lesser extent materials. In general, the transversal and multidisciplinary areas give rise to most problems.

- Implementers : these are the mass of the engineers and technicians who have to use new inventions and tools and transform them into profit-generating products and services. The first important issue is to give these people a sufficient general background education that will allow them to use and exploit the varying technologies which they will face. They should be equipped with the hybrid skills required in the changing industrial environment. It does not seem to be evident that many receive such a type of education. The second issue is the possibility (probability ?) that the overall output of the educational system will simply not be sufficient.

  A survey of implications of industrial, technological and occupational changes in Italy showed that individual workers are increasingly performing multiple functions within one job. Across the whole band of occupations covering intermediate and higher level skills, currently filled by either secondary school leavers or universities, there is a "training gap" emerging. It is questionable

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[12] However, in some countries this has been compensated by larger number of technicians.

[13] This topic is explored in the IRDAC report on school and industry.

whether the non-university higher education schools, recently established to fill this gap, will be able to do so, both qualitatively and quantitatively.

To summarize these points all evidence points to a greater need for engineers, scientists and technicians in the future, and the current fear is that the education and training systems will not be in a position to deliver the number and range of school-leavers and graduates required. Moreover, without appropriate measures, the situation will worsen in the first decades of the 21st century. Worse even, skills shortages could become so severe that they significantly decrease Europe's competitive position.

However, raising the quality and quantity of employees with a solid technology background alone will not suffice. It is generally not sufficiently appreciated that "non-technical" people, today and increasingly in the future, need a much better understanding of technology. This holds especially for managers who have to make an increasing number of decisions with regard to technological developments they might not understand. Most managers have received their basic education long before the technological revolution of today, and many of them have insufficient understanding of the opportunities new technology can offer.

A second, related issue is that increased use of technology not only offers a range of new opportunities for economic growth (at micro- or at macro-level), but also requires a serious reconsideration of the use of resources. As has been demonstrated earlier, the demographic situation and the expected growth are such that they will lead to a very tight labour market situation, and will require an optimum use of human resources. The basic education system can only deliver part of the required qualifications employees will need during their working life. Hence, it is evident that the pace of the technological change puts an increased responsibility on enterprises to make sure the workforce has the right qualifications and skills. Inevitably, this means a rethinking of the human resources and training strategies in enterprises, large and small, in manufacturing or services, which should result in increased efforts for training.

However, a higher skilled and better trained workforce is not the only ingredient to make the introduction of technology a success. The same technology can be used in different ways with different impacts on the organization of work. In fact, the introduction of new technology can only be transformed into increased competitiveness if companies also modify their work organization[14]. Such strategic choices, which should lead to the development of new production concepts[15] and management models, are a key requirement for further growth. Many companies have still a long way to go in this respect. National industrial cultures may foster new production concepts and the growth for highly skilled technologists in certain countries while retarding it in others.

In a recent Danish report, an analysis of structural labour market problems underlined these conclusions. It was reported that at least a 4-fold increase in continuing training was necessary to cope with the current and anticipated challenges. Results of other studies highlight the fact that changes in the structure of the employment market will move in favour of those with a higher training culture. The increase in training will be an economic imperative to strengthen the weak industrial base.

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[14] Section 3.1. develops in more detail some of these aspects in relation to the service sector and management.

[15] The notion "new production concepts" applies to manufacturing, but similar concepts are as necessary in a service environment.

In conclusion, the absence of change at management levels could make the introduction of new technology counter-productive. What this indicates then is that perhaps the biggest challenge presented by technology advance is not the acquisition of the knowledge itself, but rather a need for training in the management of technological change. There are many who fear that the limited understanding of many European managers of the nature of technological innovation and its human resources implications could become a main obstacle for successful adaptation of European industry to the changing economic and industrial environment.

Section 3 : Different challenges by sector and country

In this section we leave the general arguments of the previous section to look at the skills issue in specific situations. First, a number of sectors are described to demonstrate the crucial importance of human resources and adequate skills levels. These sectors are to be considered as examples of the nature of the skills issues which to a varying extent apply to all sectors of the economy. The texts are descriptive, and include no quantitative forecasts, given the lack of accurate data. However, to give an impression of the size of some of the problems, an example is included on the demand for IT-professionals in Japan.

The second part of this section considers differences between Member States. Here, a number of factors are considered which show the wide differences between countries. No country-specific analyses are given, but the factors highlighted are sufficiently indicative to show that skills shortages in the European Community are a challenge for all Member States, though its implications vary considerably.

3.1. Examples of sectoral implications[16]

New technology penetrates at a growing rate all traditional fields and sectors. While no technology has such a pervasive effect as IT (Information Technology) and telecommunications, many other areas will be subject to changes in qualification requirements and thus to potential skills shortages. The areas which are described here serve as examples for the challenges in numerous areas, and to highlight the types of problems that have to be faced.

Information technology

There is a widespread recognition that Information Technology (in its widest interpretation, including both microelectronics as well as software applications across all sectors and telecommunications) is at the heart of the current wave of technological change in Europe and other industrialised nations[17]. No doubt it is the dramatic decline in processing costs that is at the core of the pervasive and all-encompassing impact of IT.

The IT-sector is still expanding and the definition of what it comprises has not reached a final state. It cuts across both manufacturing and services and can be classified into IT-producers and IT-users. The size of the IT-using sector is much larger than the IT-producing sector (e.g. in the case of the UK it is estimated 4 times as big) and growth is particularly taking place in the services part of the IT-using sector.

The main characteristics of information technologies can be summarised as follows[18] :

- A continuing high rate of technical change in electronics-related industries, as well as in a wide range of applications. The convergence of a range of technological developments means that the

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[16] Section 3.1. is compiled to a large extent from sources referred to in the Annexes.

[17] Other generic and enabling technologies which are often quoted, though currently considered of less impact are : Biotechnology, Materials, Space and Nuclear Technology. Note that all of these are also heavily dependent on information technology in their research, management and control systems.

[18] Source : New technologies in the 1990s, OECD

power to communicate, process, control and store information is still increasing very rapidly at a price that continues to fall.

- The capability to improve the quality of products, processes and services, as well as the development of completely new processes and services.

- The capability to link up networks of component and materials suppliers with assembly-firms (e.g. motor-car industry) or with service firms. Such links permit savings in inventories, and a more rapid and sensitive response to daily changes in consumer demand.

- Much greater flexibility in rapid model changes and design, which makes small production runs more economic and thus improves the prospects for small and medium-sized firms.

- A reduction in electromechanical components and in stages of component transformation. This leads to savings in materials and energy, but also to structural shifts of employment from the metal and metal goods sector to the electronic sector and producer services.

- As a result of these developments, there is a trend towards a more rapid rate of product and process change and more intense technological competition.

The implications for skills are obvious : an increasing demand for new skills and services in design, development, software engineering and micro-electronics generally, affecting both in house skill and employment profiles and the growth of new services, information flows and equipment suppliers.

Can one quantify or qualify the employment and training needs which are the result of all these changes ? At Community level, a major study is under way but was not yet available for examination. However, research done at Member State level show already that the problem is complex and wide ranging, but in any case acute and without an adequate overall solution. The following conclusions can be highlighted :

- Inadequate preparation in basic education (from primary to higher education) to acquaint young people with basic IT skills. Governments are considering this, but the basic education system appears to have a lot of inertia for implementing actions.

- Large shortages of advanced IT-specialists (VLSI designers, software engineers, data communications professionals), though it should be realised that this group on the whole is rather small compared to other professions affected by IT.

- Growth rates for IT-related jobs have been much higher than for other jobs (often 5-10% on an annual base), even in times of significant unemployment. There are no signs that this growth rate is decreasing.

- Programmers, data-typists, operators and preparators can be considered as "old" IT-occupations with lower than average growth and hence few skills shortages. New IT-occupations can be especially found in the field of networks and systems analysis. Such trends indicate that not only there is a need for more and new IT employees, but their skill level in general needs to be higher.

- Major efforts are required at the continuing education level to acquaint existing staff with basic and advanced IT skills, both in manufacturing and in services. More generally, all enterprises and organizations have to devote more manpower planning to IT resources.

- **Last but not least, the need for skills at the diffusion stage of IT - its widespread application across all sectors of the economy - is, both in quantitative as in qualitative terms, of much more**

concern for the economy as a whole than the shortages related to the invention and innovation phase of IT.

As an example, process control equipment - with an undeniable IT character - is heavily used in chemical industry. Robots and CAM-systems are used in the manufacturing sector. As a consequence, many shopfloor workers and operators working in such branches are affected by IT-equipment as well.

In summary, the pace of technological advance in information technology is one of Europes biggest challenges, given its pervasive effect across all sectors of economy. It will be of crucial importance to Europe to maintain and develop a workforce that can participate in the innovative developments of IT and to exploit fully its potential. However, both qualitatively and quantitatively, a skills shortage problem has arisen, and without appropriate action it will worsen.

How the Japanese intend to tackle IT shortages

In several recent Japanese reports mention is made of growing recruitment problems and expected shortages in the supply of qualified manpower. This problem appears most acute with regard to information technology, both in manufacturing and service sectors.

The forecast is that by 2 000, Japan will need more than 2 million software engineers, with an expected supply of about 1 million and hence a shortage of the order of 1 million engineers, roughly 550 000 programmers and 420 000 systems engineers. Several measures are proposed to fill this gap, in particular the increase of software productivity, training of software engineers and job conversion.

The systems engineers gap is considered the biggest problem. To arrive at the required numbers, the following measures are proposed :

- a major project "SHIGUMA" for the improvement of software productivity, particularly targeted at the number of programmers, but with also an expected "gain" of 110 000 systems engineers;
- job conversion from programmers to become system engineers (77 000 system engineers);
- an increase in the IT content in general courses in universities and colleges to triple the systems engineers originating from non-science and engineering background (67 000 systems engineers);
- an increase in the capacity of IT curricula in universities (36 000 systems engineers);
- introducing of career patterns for systems engineers until retirement (45 000 systems engineers staying longer in employment);
- other measures in companies (job transfer, use of networks, investments abroad) : 87 000 engineers.

For programmers, the main benefits should come from the SHIGUMA project (gain of 453 000 programmers), but there is also the loss to systems analysts (69 000). Other proposed measures include a small increase of the capacity of IT courses in colleges (6 000 programmers), the use of retired women (29 000 programmers) and the other measures as mentioned for the systems engineers (expected gain : 125 000 programmers).

The potential of biotechnology developments

Biotechnology is still a relatively young discipline, with an enormous potential in many areas, in particular pharmaceuticals, agriculture and food-processing. Its future market (and hence its required human resources) are difficult to quantify, but the biological sciences are recognised to offer the prospect of major economic and social impacts. One of the main reasons for quantifying the future requirements is the pervasive nature of the potential application of biology research, as well as the speed of change in this field.

In this promising area of advanced technology, Europe faces a number of specific problems such as the slow emergence of products, R&D spending lower than in the USA and often fragmented, and a lack of coherent training structures, both at R&D and application level. Overall there is a problem of structure and critical mass. These trends are worrying since it has been Europe that has pioneered many of the most important developments in the life sciences. In spite of many achievements however, Europe has shown to be inferior to the USA in breadth and depth of coverage, and in the capacity to expand rapidly in new fields and to exploit the results in industry.

> *To illustrate this argument, in the USA, the published number of employees in new biotechnology firms has grown from about 20000 in 1982 to around 200000 in 1988, a tenfold increase in a period of six years. Comparable figures for Europe do not exist, but the fragmented data which are available suggest a much slower growth rate (± 3 times).*

Such marked differences are due to a range of factors, including the one that Europe lacks sufficient human resources with the appropriate skills to develop innovative applications and commercialise them. It is a positive fact that currently efforts are being undertaken by the Community to examine the current and expected supply and demand in biotechnology manpower on a European scale, as well as the implications for skills and qualifications requirements.

> *A recent European workshop on manpower and training needs for Biotechnology in Europe in the 1990s indicated already existing shortage areas such as protein biochemistry, downstream processing, product purification, microbial physiology and bioinformatics. The group recommended urgent measures to be taken to redress the current decline in the numbers of graduates specialising in such areas.*

In summary then, on the skills side Europe faces two types of challenges:

- First of all, there is a need for a better insight in current R&D and training efforts, so that they can be integrated into a more coherent European framework. At a time that the number of postgraduates is decreasing, and that many lesser developed regions lack sufficient facilities, there appears to be a need for concerted action and increased supply of postgraduate specialists (engineers and scientists at pre-doctoral and postdoctoral level) in a number of specific areas. If no action is taken, it seems unlikely that biotechnology will develop significantly in Europe.

- Secondly, when the knowledge base has grown, there will be a growing need for generalists and technicians who can spread the technology and apply it. Shortages of technicians are now already being felt, with inadequate education structures available for them.

Materials and industrial technologies

The use of new materials is one of the most important aspects of technological innovation. For example, the advances in IT can be traced back to developments in semiconductor technology which resulted from the development of new materials. More recently, one has been excited by developments in superconducting materials made from ceramics which may further push the development of electronics and consequent applications in information technology.

Materials are intrinsically related to the processes that are developed to handle and manipulate them, sometimes called "industrial technologies". The primary customer for these technologies is the manufacturing industry, which currently provides about 30 % of the GNP[19] in the European Community. Some of the "traditional" sectors of manufacturing have invested heavily in new technology in the past few years; the move towards computer integrated manufacturing in the textile industry is a case in point. Successful manufactures are seeking increasingly to capture the top end of the market by new and improved products, usually with a higher technology content in the product itself or in its means of manufacture. Evidently, this leads to a requirement of a higher skilled work force to implement and use these advanced products and processes. In the medium and long term, success depends therefore on the availability of the qualified human resources to innovate.

While there have been numerous studies on the skills implications of the introduction of advanced manufacturing processes (CNC, CAD/CAM, Robotics, CIM, FMS), the emphasis has often been on the shortage of skilled electronics engineers and technicians, and software designers. Apparently little attention has been paid to the skills implications of new materials. Here, there are two main areas which require examination. The first is the sector of industry[20] which develops and produces new materials. The second is those sectors which will use the new materials in their products and/or processes. But in both cases it has been observed that new materials have a long incubation period - during which the people involved are working in research and development laboratories to asses its technical feasibility - before one moves into the period of commercial development. At that stage, a much larger workforce is needed.

Given these relatively long development times, the medium and long term skills implications of new materials are difficult to quantify. Short term problems can be more easily identified since they are linked to R&D efforts. It is far from evident however that the education systems - in particular the universities - have the means and flexibility to provide the researchers that are required, e.g. in areas like ceramics, plastics, adhesives, composite materials, fibres, etc. Moreover, as in many other advanced R&D areas, Europe face a problem of critical mass of the research and advanced training centres.

There are some other observations equally relevant. Firstly, it has been observed that many material developments are not radical but rather incremental in nature, with little radical implications for skills. Secondly, often "established" materials have been given a new life by new processes or other enabling technologies which have allowed them to be used in applications previously ruled out. Thirdly, research have shown that one of the main bottlenecks in harnessing the potential of new materials was related to the lack of awareness of available materials by design engineers and material specifiers. Clearly, this calls for better information, dissemination and training strategies across Europe.

In summary, materials technology is wide ranging and the importance of advanced materials and related processes is steadily growing. Major manufacturing sectors in the Community, such as the automotive and the aerospace industry are heavily dependent on the advance in material technology, and other industries, such as textile, have only remained competitive because of the use of new industrial technologies and processes. As regards skills, Europe faces 2 important challenges. First, it should make sure that sufficient R&D work in this area is done, which requires sufficient human resources to be available. Secondly, it should ensure that the new products and processes developed are effectively and efficiently implemented. This will require a much larger and higher qualified workforce than is available now, as well as increased emphasis on advanced training.

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[19] GNP : Gross National Product

[20] And to a certain extent also research institutes and universities.

Aeronautics

The aeronautical industry is not Community's largest employer, but it is a good example of a manufacturing area where Europe has become quite successful in recent years. During the period 1980-86 the European aeronautics industry captured 23 % of the civil and 27 % of the military world market. It is also an area where increased internal European cooperation is a necessary condition for future success.

It should be underlined that this success was possible because of adequate use of advanced technologies stemming from a range of innovations in materials technology, control equipment, aerodynamics, CAD/CAM etc. Crucial to the market penetration was also the availability of the skilled resources to develop and build large aircrafts.

The world market is expected to expand substantially up to the end of the century and increasing competition to capture it must be expected, not only from the USA but also from Japan and industrialising countries such as South Korea and Brazil. The USA industry remains in a particularly favourable position however, because it enjoys a large home market and it benefits from the spin-off from military R&D programmes.

In this challenging high tech environment, Europe will only be in a position to remain competitive if a long term strategy is developed that includes sufficient resources for R&D, as well as human resources strategies within the companies concerned (and their sub-contractors) that take into account the continuous upgrading needs of their personnel, from craftsmen and technicians to advanced researchers and engineers. It is evident as well that the efforts required (in R&D, engineering and training) are such that only through European cooperation can the necessary scale of effort be mounted.

The service sector

In recent years, the European service sector has become more important than manufacturing in terms of employment. There is evidence that its growth will continue, partly because of its own dynamic, but also because of sub-contracting by manufacturing and related industry of tasks previously executed themselves. New technology in services (in particular commerce and offices) has impacts which differ from those in manufacturing, though there are a number of analogies and similarities. In office jobs the main changes implied by new technology (essentially information and telecommunication technology) include increases in the volume and the pace of work, in the loss of responsibility, in the lack of control over one's own work, etc. To overcome some of these problems requires a change in work allocations to avoid functional specialisation.

> *In the Insurance sector for instance, it has proved possible to establish groups responsible for all aspects of claims in a particular geographic area rather than separate groups to handle each stage of the claim processing. Such developments could take place because the introduction of information technology made a number of innovations possible :*
>
> - *it can automate work processes that previously were performed manually*
> - *it can create new and/or flexible products in a cost-effective manner, which otherwise would have been too labour-intensive*
> - *it can permit corporate structures to use new distribution channels, decentralisation of work and flatter structures, but also continued central control.*

Studies have demonstrated that the well planned and efficient introduction of new technology in the service sectors can lead to greater complexity, more independent decision making and foster access to relevant information. The requirement is however that this is accompanied by a change in

management style, and requires the availability of appropriate skills and expertise. Note that these conditions are often not met in large public administrations.

Another service sector which is undergoing profound changes in skills requirements are banks. In the past years banks have considerably altered their recruitment practice and modes of operation. As an example of the changing qualifications, consider the next table, which is self-explanatory. It shows the changing nature of skills in banks following the introduction of technologies and new operating models.

Changing nature of skills in banks	
Old competences and skills	*New competences and skills*
General	
Ability to operate in well-defined and stable environments	Ability to operate in ill-defined and ever-changing environment
Capacity to deal with repetitive, straightforward and concrete processes	Capacity to deal with non-routine abstract work process
Ability to operate in a supervised work environment	Ability to handle decisions and responsibilities
Isolated work	Group work; interactive work
Ability to operate within narrow geographical and time horizons	Comprehensive grasp of systems; ability to operate within expanding geographical and time horizons
Upper-tier workers	
Generalist. Broad, largely unspecialised knowledge; focus on operating managerial skills	*New expertise.* Growing need for high-level specialised knowledge in well-defined areas
Administrative. Old leadership skills; routine administration; hierarchical personnel management; ability to carry out orders from senior management	*New entrepreneurship.* Capacity to not only manage but set strategic goals; to share information with subordinates and listen to them; to motivate individuals
Middle-tier workers	
Procedural. Specialised skills focused on applying established clerical procedures	*Customer assistance and sales.* Broader and less specialised skills focused on assisting customers; selling capacity; define and solve problems
Lower-tier workers	
Specialised skills focused on data entry and data processing	Disappearance of low-skill jobs

Management and organisation

Management is not a "sector" as such, but is included in this section since the pace of the technology change affects the way organizations are managed. In fact, new technologies and in particular IT are not only affecting the structure of the economy in terms of new industries and services, but also the internal structure and management of all enterprises and the relationships between them. There is a tendency in the more successful firms towards the horizontal integration of R&D, design, production and marketing (and similar developments in service companies), as opposed to the traditional Tayloristic pattern of vertical, hierarchical control.

The relationship between new technology and work organisation is characterised by great diversity as well as mutual dependence. New technology has the promise to change radically the way work is organized in many institutions - and has already done so in an increasing number of enterprises. The increased and growing implementation of quality circles is one of the more obvious demonstrations of this phenomenon. The direction and extent of change, however, is difficult to predict as it depends on a range of factors - among which managerial strategy stands out as the most important.

To implement new technology successfully, careful attention to personnel and industrial relations issues is an essential complement to the broader thinking required for technical and organisational change. The managerial cultures that prove least effective in the latter respect are also likely to fall down in the former. Extent and speed of innovation heavily depend upon the organisational context, particularly the qualifications, attitudes and structure of management. Obviously, the demands made upon organisations and individuals to implement large scale innovations are extensive, and no doubt many enterprises do not have the required technological and management resources.

> *Studies show that short term, often only partial responses, are particularly likely when management lacks an adequate background in systems and product engineering, when departmentalism is marked, when the intricate links between technical and organisational change are not appreciated and when Tayloristic orientations prevail. The interesting results already attained by some enterprises, notably in Japan and the USA, but also in Sweden and Finland, reflect a combination of attributes and skills that the enterprises of the European Community will need to adopt if they are to remain competitive.*

3.2. Differences across Europe

In Section 2, the European Community was treated as a whole (like the USA). However, differences across Europe are still significant, which implies that the prospects and necessary approaches will also vary considerably. In the following paragraphs, we look at some of the overall differences with regard to demography, labour demand, technology manpower and educational attainment.

To illustrate the differences in demographic developments, Figure 10 (next page) shows current (1985) and expected (2025) dependency rates for each of the 12 Member States of the Community[21]. Currently the overall dependency rate in the Community is at 50 %, roughly divided into 30 % youth and 20 % old dependency. Some Member States have a higher dependency rate, in particular because of a relatively young population (IRL, E, P). By 2025, the situation will have changed dramatically. With an increased average in EUR-12, the three countries mentioned will face lower dependency rates than now, but most other countries will see them increased, because of the ageing of the population, in particular in B, D, DK, F, I and NL.

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[21] It is recalled that the dependency ratio is the ratio of the number of people in age groups <15 and >64 to the number of people in age group 15-64.

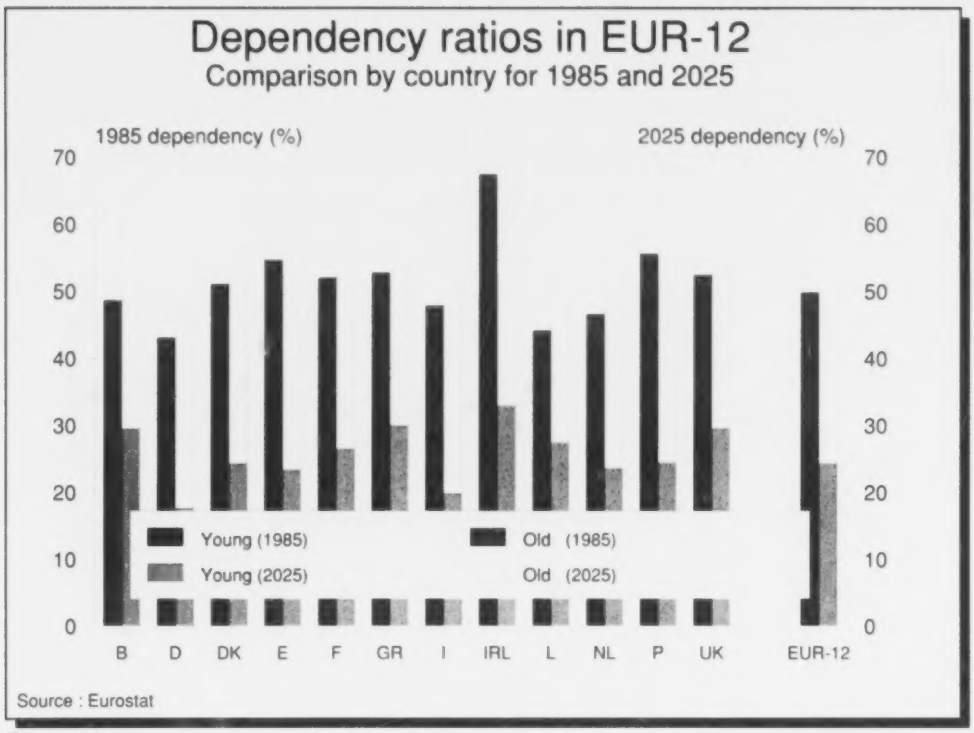

Figure 10

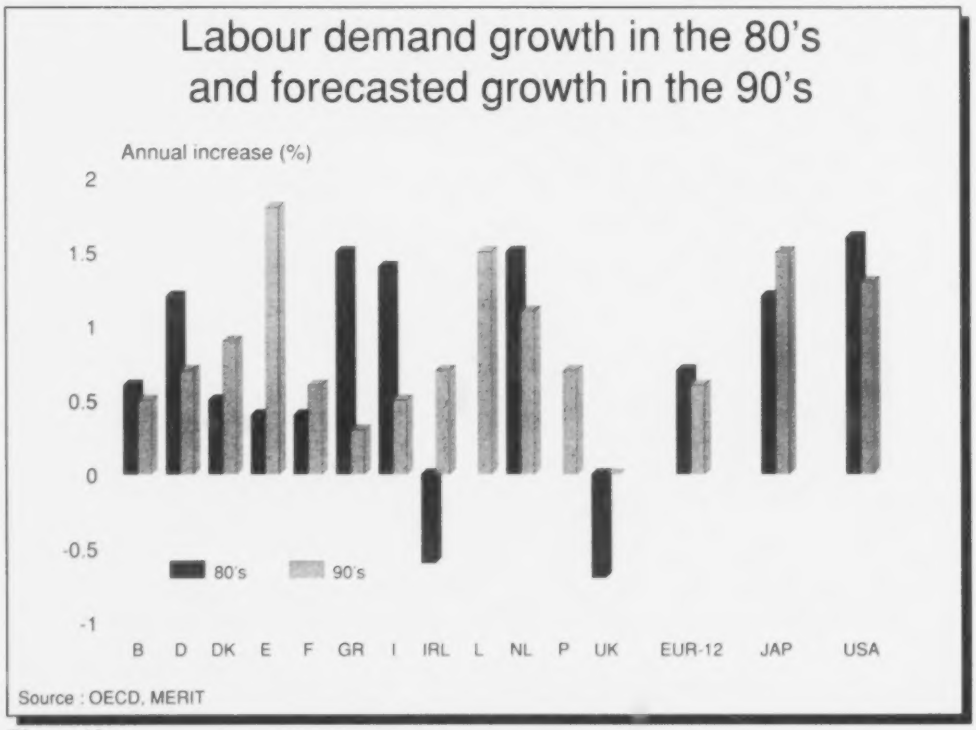

Figure 11

These demographic developments - which do not take into account potential immigration movements - should then be compared with the labour demand. Projections after 2000 are difficult to make, but a comparison between the 80's and the 90's has been made by the OECD. They are displayed in Figure 11 (previous page) for the countries of the European Community, Japan and the USA. Note that most European countries are close to the EUR-12 average, with significant higher figures for Spain, Luxembourg, and to a lesser extent NL and DK. The figures should be treated with caution, since they relate to different current economic realities (compare e.g. the Spanish with the Japanese situation).

This then brings us to the overall matching of supply and demand for the coming decades. In Section 2 it was stressed that such a process is difficult to forecast, but that given the current level of demand and the expected growth, it appears that there are no obvious signs of widespread quantitative gap emerging between supply and demand in the 1990's for most Member States, with maybe some excess supply for countries like Ireland and Spain. Notwithstanding this relatively encouraging overall result, IRDAC observes that :

- scenarios and projections existing for several Member States show that many countries already in the next ten years will be faced with overall labour shortages
- the situation is likely to worsen considerably after 2000 for most Member States (unless there is economic stagnation)
- for specific sectors - in particular high tech areas - all Member States are already in short supply and there are little signs of significant changes
- the overall picture (± equilibrium of demand and supply) hides the shifts in skill requirements as well as structural mismatches; it is unlikely that the rate of change of the employment profiles in each of the Member States will find an adequate response from the national education and training systems.

IRDAC also observes that the current scenarios and forecasts for Member States are often solely based on assumptions like productivity growth and market demand. It is recalled here that other variables are often neglected. For instance, the technology push and increased educational attainment leads to other qualification profiles and employment distributions. A heavy increase in software productivity (as now under development in Japan) could radically change the needs for IT-staff.

Another aspect are the changes which are now taking place in Eastern Europe. It is clear that these will have implications on market developments and even immigration and hence on the required skills. The measures to be implemented to bring these countries to Community level, will require a major effort for human resources.

No Member State will escape from the general need to increase the educational attainment of its population. Data available for different countries (but not always comparable because of varying education systems) indicates widespread differences. All data show however that Europe lags behind Japan, and that newly industrialised countries like South Korea and Singapore are catching up, mainly through first raising the average school-leaving age of the young and then producing increased cohorts of higher education graduates.

In all Member States, the female population still has a lower educational attainment than the males; however, differences have become small for the younger females, who are reaching the same higher education penetration than men (but mostly not in the same disciplines; in fact, even amongst the younger generations, the participation of women in engineering is quite low - this holds to a varying extent for all Member States).

Differences across Europe in educational attainment are large, with notably low figures for the Mediterranean countries. Only Spain seems to be catching up in the coming decades, but in Portugal significant measures have now been announced. Regarding Italy, the problems of university students with regard to eventual graduation or timely completion of degree studies, as well as the almost non-

existence of a non-university sector (which is currently being remedied) seem to be serious obstacles for improvement. What is evident is that such countries on the one hand have a wider pool of talents to build on, but on the other hand, might need more structural measures to harness this potential.

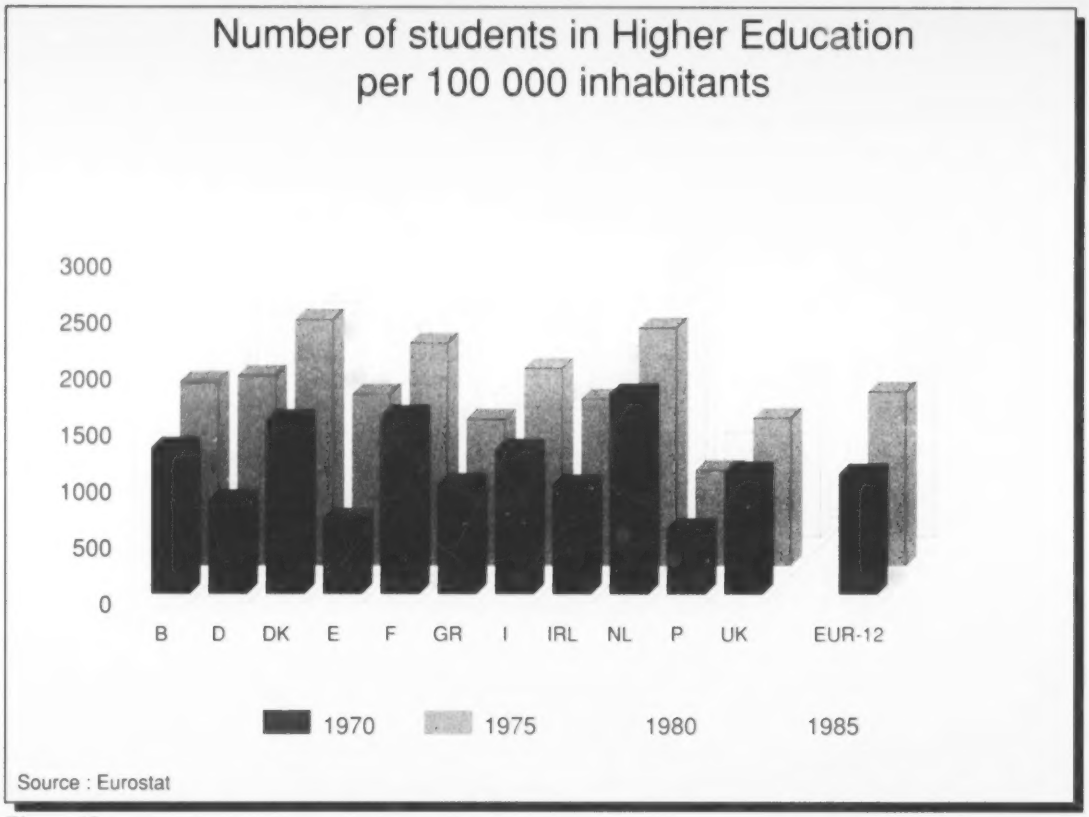

Figure 12

The figures on student participation in higher education are a good indication of the progress that has been made with regard to the change in educational attainment. Figure 12 shows these figures. Note that in the early 70's the differences between Member States were much larger than they are now (before 1970, they were even higher). In 1970 the highest figures were obtained in DK, F and NL and growth in these countries has been lower. Significant increases have to be noted for D and E, while P and to a lesser extent GR, UK and I have not been moving up in the same way as others[22]. It implies that these countries could be faced with higher advanced skill level shortages than others. On the other hand, for the countries with much higher numbers (e.g. D, NL, B) the concern has been expressed that there would be too many higher education graduates (notably in disciplines for which the demand in society was low).

This brings us then to the match of the supply and demand of technology skilled people. Though certain studies exist that examine the demand and supply for a particular country, no comparative complete data exists which allows an analysis of whether certain Member States are likely to face more technology related skills shortages than others. There is some incomplete data available concerning

[22] These figures should only be considered as rough indicators, since they concern completely different educational systems (with differences in the standards and graduation rates of the various education system components, e.g. it is well known that in the UK the study periods are much shorter than in D, I and NL).

engineers and scientists and the next table shows the proportion of natural sciences and engineering within universities, as well as the share of engineers in the labour force[23].

Measures for the relative importance of engineering and natural sciences				
	Share of engineering in universities (% of students)	Share of natural sciences in universities (% of students)	Total	Engineers as part of the labour force (in %)
B	11.4	10.3	21.6	2.0
D	14.1	18.1	32.2	2.2
DK	20.1	9.8	29.9	1.4
E	10.5	11.5	22.0	
F	7.1	12.9	18.7	1.2
GR	16.1	15.1	31.2	
I	18.3	12.9	31.2	0.4
IRL	17.1	14.3	31.4	
NL	16.3	12.0	28.3	1.8
P	18.5	7.0	25.5	
UK	16.7	22.8	39.3	1.0
EUR-12	15	13	28	1.4
USA	5.9	11.6	17.5	1.4
Japan	21.6	3.2	24.8	2.5

This table is only indicative and an approximation for EUR-12. For a good interpretation, it should be noted that the first columns only relate to universities, and do not include other types of higher education (e.g. Fachhochschule (D), I.U.T. (F), Hogeschool (NL), T.E.I. (GR), etc.). It shows nevertheless the major differences across Member States, even if one realises that in certain countries the non-university engineers and/or higher technicians make up some of the differences. The first columns illustrate the differing positions of engineering and natural science education within overall provision. In all European countries, except F and the UK, engineering has a larger share than natural sciences (this is however compensated by the education of engineers in polytechnics in the UK and higher technicians in France). There is little variation in the relationship between engineering and natural sciences, but no EC-country is at the level of Japan (6 times more engineers than scientists).

The last column shows the share of engineers (both university and non-university higher education graduates) in the total labour force. Here we see serious differences : certain Member States have more than twice the number of engineers than others (in general the numbers of scientists compare in the same way), reflecting the current labour market situation. Given the current output rates of educational systems, it seems unlikely that Member States which have lower numbers (I, UK, and to

[23] The data is derived from a wide range of sources. In general they relate to the beginning of the 80's and have changed since; however, most changes have been proportional and therefore do not affect the differences between countries.

a lesser extent F and DK) can attain the same numbers in the next decade. They might therefore be in a weaker position to cope with technological change. In relative terms, Europe is at the same level as the USA, but lagging far behind Japan.

As mentioned, structured and comparable data which allows an analysis of differences between Member States regarding the demand for skills (in particular those related to the implications of technological change), are not available. With regard to the need for the innovators (as defined in Section 2) who will implement the R&D tasks that will be necessary, one could take as a starting assumption that the current differences between Member States will still roughly be the same for another decade. The following table with figures on current expenditure on R&D, the number of researchers as part of the labour force and a composite index on R&D (based on a consideration of different factors) is an indicator of the current variation between Member States.

Indicators of R&D skill needs			
	R&D as a % of GDP (1987)	Researchers (per 1000 employed)	Composite R&D index (EC = 100)
B	1.5	2.6	76
D	2.8	4.8	131
DK	1.3	2.7	68
E	0.7	1.0	18
F	2.35	3.9	108
GR	0.35	0.6	/
I	1.5	2.7	61
IRL	0.8	2.8	53
NL	2.3	3.7	103
P	0.4	0.7	/
UK	2.3	3.1	106

In addition, Figure 13 (next page) shows the absolute and relative number of researchers according to a recent survey. The table and the figure clearly show the varying degrees of current R&D effort and high-tech developments in the Member States. Most R&D activity is currently taking place in D, UK and F[24], with highest figures in Germany, which alone employs 35 % of Community R&D personnel. If these trends continue, these countries will need increasing investment in human resources to deliver the necessary numbers of high level scientists and engineers. If other countries (such as B, I, DK, E) wish to arrive at the same level, a major effort will be needed from government (financing of R&D expenditure), universities (increasing significantly the supply of R&D staff) and enterprises (developing more R&D activities). It seems unlikely that most countries could close such a gap by 2000, given the resources involved, even if the European Community were to boost its efforts in this area. Figure 13 also shows that in absolute terms Europe has more researchers than Japan but less than the USA. Per head of population, the European figures are less than half of the nations mentioned. Countries like South Korea and Singapore (not displayed in the figure) are already at the European average (per head of population) and are progressing fast.

[24] As well as in NL, but the country is much smaller in size.

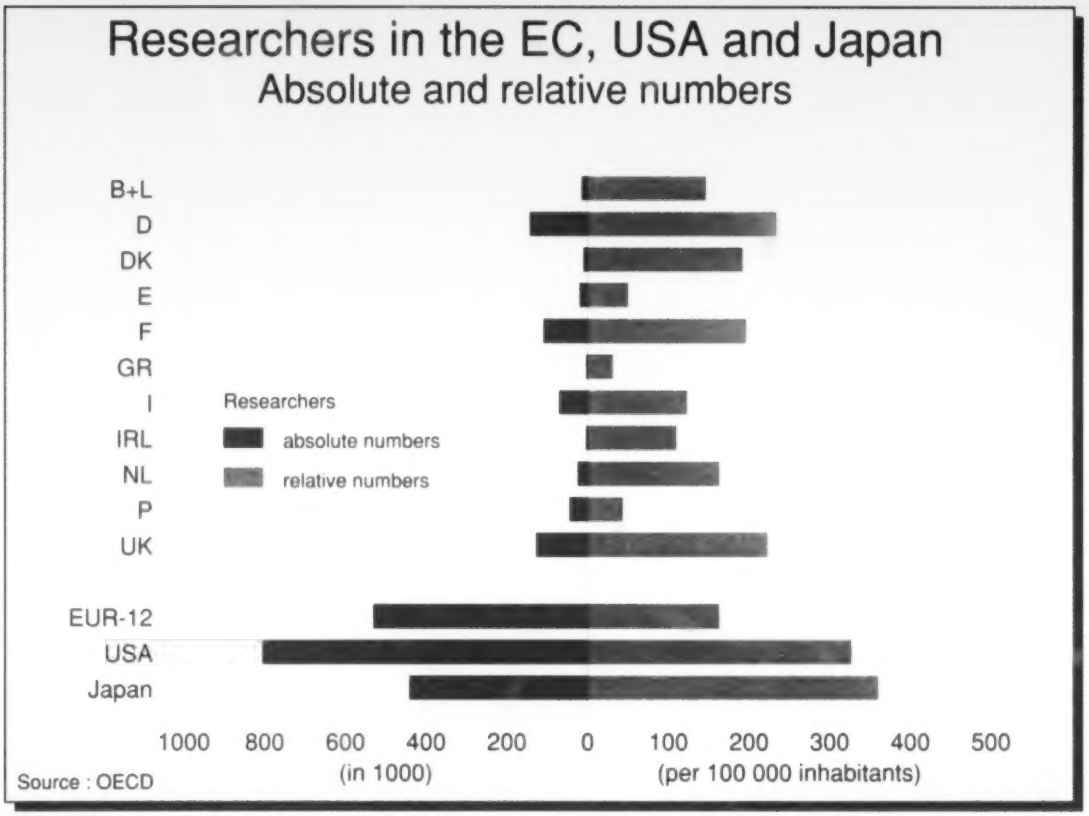

Figure 13

In summary, the main quantitative skills shortages will in the future remain with the technology "implementers", as defined in Section 2. For "innovators" the challenge is to educate highly specialised people, but in relatively small numbers. It is therefore essentially a problem of expenditure in private and public policies. Member States and the Community can therefore implement targeted measures. For the "implementers" however, the problem of skills shortages is one of need for large numbers of people with new qualifications.

The differences across Member States are difficult to quantify since they depend on the economic structure of the country, the level of modernization of the manufacturing and service sector, etc. Real comparisons cannot be made, but the data presented in the foregoing paragraphs on educational attainment, skilled labour demand and output of engineers and scientists suggest again that the more developed regions in the centre and north of Europe are in a much better position than the lesser developed parts of the Community. Since the application of new technology requires less investment than development, it should be easier for the European Community to assist in spreading the supply of the information and training required for application of new technology across all of its regions than spreading investments in high tech R&D. This supposes however that the lesser developed regions adapt their education and training structures in such a way that they can deliver sufficient numbers of technicians, scientists, engineers and other graduates that can understand, use and apply the new opportunities provided by technological developments. If they do not, there is little that would prevent a brain-drain of highly qualified staff to more developed regions, a movement which would not be in the interest of the countries concerned, and indeed of the Community itself.

Considerable migration from Greece, Spain, Portugal and Southern Italy towards the north of Europe took place during the 1950s through to the 1970s. The migratory flow has now ceased and even reversed, with the return of migrants as well as the arrival of workers from outside the Community. However there are now pressures for emigration re-emerging, in particular for highly qualified people (already noticeable moves in Northern Italy of bright young people to Germany and Switzerland). Countries like Greece and Portugal without a diversified economic base will become under severe pressure to keep their talented workforce. More investment in continuing education and training and in the research infrastructure will be a key factor to optimize and keep their best resources.

Section 4 : Conclusion and recommendations

The previous sections analyzed a number of factors that affect the skills shortage problem :

- *demographic developments that will lead to tighter labour markets*
- *the impact of advances in R&D and technology*
- *the requirement for a rise in educational attainment and a growing need for new and multidisciplinary skills*
- *the opportunities and challenges of European integration*

All evidence points to the fact that skills shortages caused by these factors are growing and will do so in the coming years at an increasing rate, if no corrective actions are taken. Worse, the competitiveness of Europe is at risk unless adequate responses can be found for these challenges. Europe cannot afford to remain inactive : if no corrective actions are taken, the potential of the Single Market could be lost.

This section suggest directions for action to remedy some of the disturbing trends. None of these is a miracle solution to what is a complex problem, and none will be easy to implement. The problems have not the same dimension in each of the Member States, and therefore solutions should be considered having regard to the particular nature of the problems in the country concerned. A similar remark holds with regard to certain sectors where the problems are more acute than in others. IRDAC remains convinced that the issue should be considered as a whole in order to avoid the trap that the solution of one set of problems could create problems elsewhere. Current and anticipated skills shortages are such a threat to Europe's competitive position that immediate action is required from all parties concerned:

- *authorities and administration at Community, national, regional and local level*
- *enterprises, both in industry and services (including public services), whatever their size or sector*
- *the education sector, in particular the higher education and continuing training sector*
- *the individuals themselves*

Only an overall and sustained approach by all these actors will lead to adequate responses.

4.1. Continuing training for the existing workforce

Challenges for all

Though most of the technology that will be used in 10 years' time needs still to be developed, by 2000, at least 80 % of the current employees will still be part of the labour force. IRDAC believes therefore that a substantial proportion of the corrective action should go to this group, in particular towards its older part which is lower qualified and which came on the labour market before the current technological changes. Given the decreasing supply of young people (though on the average better qualified) and the pace of technological change, a massive investment in upgrading of the existing workforce will be needed.

What does this mean for the actors concerned ?

- For governments, this will imply a shift in their priorities for education. National governments and the European Community should reassess their policies in this regard and give increasing importance to raising the basic level of education and preparing the workforce for continuous upgrading through appropriate training possibilities. Special attention will be needed for the growing group of older, relatively low skilled persons, who are often out of employment and may stay in unemployment for ever. The states have an important role to play in providing access to continuing education.

- For most industrial companies and services (public or private), it will mean a reconsideration of their development strategies and the importance they give to the training of their workforce. Retraining and updating of employees will require a joint responsibility of all actors involved and industrial associations have a key role to play here (in particular regarding SMEs). Social partners should agree on the growing importance of continuing training for the competitiveness of companies. This does not mean necessarily that enterprises have to organize their own training - since it is not their core business - but that they have a responsibility for the updating of their employees. Analyses and case studies known indicate that, if introduction of new technology is accompanied by appropriate training schemes and upgrading of the workforce, employment over time increases.

- Universities and higher education establishment will have to develop much more fully the continuing education axis in a variety of formats. Continuing education should become a mainstream activity of the higher education sector, which will have to assume an increasing responsibility in this area. In that respect they will have to develop more structured cooperation with enterprises in the field of education and training. Such a cooperation should lead to an optimal use of resources in both universities and enterprises.

- Individuals should realise that a basic diploma is no longer a guarantee, let alone a key for a successful professional development. They will have to develop attitudes on the need to update themselves regularly in a more structured way than before, since the acquisition of professional experience alone will be insufficient to be kept up to date. The willingness to follow training, partly on own initiative and during free time, will be an important factor in improving employment productivity and advances in individual development. Updating and retraining should be considered not only as a right, but as a need and a social duty. Society (in particular governments, but also companies, teachers and trade unions) has an important role to play (e.g. through the media) to impart these ideas to all members of the work force, to make sure that individuals are sufficiently motivated to learn.

In summary, all this comes down to a need for a change of attitudes of everybody : individuals, universities, enterprises and government.

Major efforts at stake

Solutions "on the ground" will require considerable efforts, since a whole range of problems needs to be overcome. Appropriate actions are called for at both national and European level. IRDAC does not want to express views on the varying requirements of individual Member States, but would like to mention in the following paragraphs a number of general issues which are relevant for all Member States. In addition, under section 4.3. a number of themes have been grouped which require action at European level.

- One of the most critical issues to be tackled first is to raise the awareness of the problems in the general population and with the actors concerned. Governments, enterprises, universities and individuals should be made more knowledgeable about the technological changes in front of them, as well as the immense training implications following from it. This, of course, will not be easy, since most organizations and individuals have not grasped their full consequences. In particular, industry should recognize that training is essential to maintain the effectiveness of its employees and to enhance their possibilities in step with accelerating technological change.

- Any concrete action will have to start with a consideration of the fragmented nature of the continuing training market. Though the situation varies across countries, the current supply of continuing training is generally little known, scattered, incomplete and not always of high quality.

Certain fields, such as management training, are heavily commercialised and often only directed towards large companies. No major progression in continuing education and training can be expected, if the market supply is not better structured. Better inventories of training provision and cost-efficient possibilities are urgently needed at local, regional and national level. In addition, special efforts should be made to undertake activities at European level, in particular as regards highly specialised sectors, where training supply and demand merits a European character. IRDAC welcomes the fact that in various European Programmes (in the education and training area as well as in R&D) such actions are already taking place, but recommends that more should be done. Such information will help to provide a better assessment of strengths and weaknesses of training provision in the sectors concerned, and provide a better base for remedial action.

- Better inventories should form the base for support for more structured and well coordinated forms of continuing education and training across Europe. IRDAC feels that the current provision is totally inadequate for meeting the anticipated demand for training which, as is already happening in the USA, could well quantitatively exceed the whole classical basic education sector, from primary to higher education. This demand implies that higher education institutions will need to adopt and profit from adult training as a mainstream, rather than an ancillary occupation, but also that companies, either alone or with related organisations, develop the specific training actions for the specialised topics they can only handle themselves. What is essential here is that structures exist that can deliver the range and volume of training required, and can adapt quickly to evolving needs.

- The subject areas for which training and retraining actions are needed will vary, according to the particular situation and the particular target group : state of scientific and technological development, nature of the changes implied by technological advance, skill level of the current manpower, surpluses and shortages on the labour market. In these recommendations no specific areas are highlighted but it is stressed in particular that all technology areas (and broader, all areas affected by technology, in particular IT) risk to be faced with skills shortages in various degrees. For costly education and training efforts in advanced technology special programmes need to be developed, and some of the existing national and European programmes already have gone some way in meeting that demand (see also Section 4.3.).

- In addition, however, IRDAC would like to stress that major training activities are needed to combat "technological illiteracy" for people with a non-technical background, so that they are in a better position to understand the challenges they are exposed to. This holds particularly for management. A considerable increase in resources is needed to instil managers with innovation and technology management, so that they can implement the necessary organisational changes (both in manufacturing and services environments) which are needed for the introduction of new technology. Without accompanying measures in training in management of technological change Europe could well not profit from the advantages of the new technologies and applications of R&D, even those that were developed within Europe. This implies that steps are taken to increase significantly the provision of more flexible modular courses on these topics, with easy access for busy managers at all levels and in all types of enterprises, large and small, private or public.

- IRDAC feels that by the 21st century, training measures for those at work will not be sufficient to cope with the demand for trained and skilled people. Therefore, it seems likely that the participation rate in the labour force will have to be increased. It has already proved necessary in certain regions of Europe (and the numbers are increasing) to attract more people into the labour force (often in part-time employment), such as :
  - *low skilled and unemployed people*, after giving them the possibilities and means for upgrading;
  - *middle aged women*, who come back to the active labour force once their children have reached a certain age;
  - *older people*, in particular people which have reached the retirement age, but could still have

an active contribution to the labour force
- *migrants* (both within or from outside Europe)

IRDAC does not wish to give an opinion on the social issues that might be raised by some of these approaches, but underlines that governments and companies should be prepared to accept the practical and social implications that arise. For instance, attracting middle aged women will require special training measures (before and during re-entry in economic life), but also more flexible work arrangements and measures such as provision of children nurseries linked to companies. For elderly people, part-time schemes could be envisaged, rather then having them retire fully from one day to the other.

- Finally, whatever measures are taken to retrain and update the workforce, they will require a massive increase in adult trainers. Except within the large companies, such people are scarce. To increase the number of trainers (which is a common responsibility of both governments and companies) there are few viable approaches (and it will not be eased by the demographic evolution). The main bottleneck is in fact the training of these adult trainers. To IRDAC it seems that there is a need to create new structures in the European context for the education, training and updating of industrial trainers. Part of the "student pool" for such institutes could come from existing trainers of the basic education system (from primary teachers up to university lecturers) to become adult trainers. Also, it seems likely that many industrial staff will have to become "trainers" for part of their time, but lack the necessary skills and methodology to do so. Part of the solution could be found in using older employees as trainers. What solutions are implemented will vary from case to case; however, IRDAC stresses that action is urgently required.

In summary, IRDAC recognises that the measures proposed in this section will require substantial investments. In particular, the increase of the pool of potential employees will be costly, and is to some extent a matter of social policy. However, advances in technological developments - eased by higher annual cohorts of new highly qualified people, as discussed in the next section - can only be converted to competitive advantages if all employees have acquired the level and range of skills to use and exploit technology.

4.2. Adequate skills for the young entrants on the labour market

Initial education

Though measures concerning the existing workforce are important, they should not be at the expense of measures for the new entrants on the labour market. In fact, young people will still be one of the main carriers of innovation and technological renewal, provided they leave the education system with up to date knowledge, and even more, the right attitudes. Advanced industrial R&D, in which Europe is still lagging behind its main competitors, is one of the keys for Europe's competitiveness, and increased efforts in that direction will mainly rely on the supply of young researchers (the measures proposed in the previous section - in particular concerning the older and less skilled part of the workforce - would probably have little effect for advanced R&D, and would probably not be very cost-effective). Newly qualified engineers and scientists should be fully equipped to make an early and effective contribution to the European industrial effort.

IRDAC therefore recognises the need for a balanced effort towards initial education of students, as well as continuing training of people at work. The focus on skills shortages, which is crucial in the short term, should not be at the expense of the long term requirements of society, for which the solutions have to be implemented at initial education level. Despite demographic trends, the supply of highly skilled people in Europe should be maintained and even increased. Sufficient young people should have received the right level and type of education, and adopted the right attitudes towards

their future career prospects and possibilities by adequate and up-to-date initial education. IRDAC believes that the use of new technology based training tools, combined with a substantial and sustained increase in distance learning are some of the keys in the search for solutions for this problem.

Attracting the young people

IRDAC is concerned about the current supply prospects. Even with growing educational attainment of the labour force, over the past few decades the pool of potential candidates for highly skilled studies and careers has been shrinking, due to the decreasing average mathematical and technical abilities of school leavers.

- It is a big challenge for Europe to attract more able students into mathematical, scientific and technical streams in primary and secondary education[25]. Only in this way can it be guaranteed that in the long term there will be sufficient pool of graduates from which to draw the graduates that Europe will need. IRDAC underlines that the great attention paid to primary and secondary education in Japan, and in particular mathematical attainment, is one of the main factors that has contributed to Japan's current economic position, and that countries like South Korea are moving in the same way. The European Community and the national governments are therefore asked to increase considerably their efforts in this direction, in particular by encouraging more females to enter more science and mathematically based study paths at school. New educational tools, such as user-friendly multimedia packages, should be used and exploited to a much larger extent.

- IRDAC also observes that children with "manual" family backgrounds do not take part in higher education to the same extent as those from other social classes. Since this is partly a financial problem, it is strongly advocated to support able but disadvantaged children to use the higher education possibilities. It could prove to be a cost-effective method of increasing the available technically qualified manpower and of reducing future unemployment.

- Universities should be given the capacity to expand in the technical and scientific fields, to increase the higher number of graduates required (and to develop more continuing education activities, as mentioned in section 4.1.). Quantitative expansion is however not enough. Industry expects graduates with a solid foundation, but also a high capacity for adaptation, creativity, mobility, flexibility, teamwork. In that context, universities are asked to assess whether their curricula are sufficiently broad and not overspecialised, and to guarantee that attitudes like team work, flexibility, creativity, adaptability, communication abilities and languages are imparted to students by the type and the nature of the study programme offered. Students need to become more aware of the industrial and European environment in which they will have to work. IRDAC welcomes the European programmes which promote mobility and industrial experience (in particular COMETT, ERASMUS, SCIENCE, BRIDGE, ESPRIT which are all promoting mobility, but with different target groups), but finds they need to be accompanied by greater complementary support at national levels.

- Technological skills shortages do not only concern engineers and natural scientists. IRDAC considers that no young should leave the educational system without some basic understanding of science and technology. Technology will become an ever greater part of the culture of society of tomorrow, and young people who have no understanding of its impact and its potential use

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[25] This issue is developed at length in the IRDAC report on Schools and Industry, and is related to issues such as the perception of technology, engineering and industry by society in general, and by teachers and pupils in particular. The report recommends a series of actions to attract more students into the technical and scientific stream in education.

will have severe problems in functioning in society. A second overall concern is that, in the 21st century, nobody in Europe should leave the educational system unqualified or unskilled. Europe will not be able to afford the costs and obligations resulting from a mass of low or unskilled people. This is a major challenge, in particular in certain countries, but is a long term effort which will bear its fruits. A particular concern for the European Community should be to make sure that the human resources stock in less developed regions is harnessed and used to its full potential.

- Finally, it will always be unavoidable that some young people will come on the labour market with the right attainment and attitudes, but with the wrong qualifications and specialisation. Structures should be set up to retrain these young people towards functions which are more needed by the economy, rather than, as usually happens now, condemning them to unemployment or underemployment in occupations they have not been trained for. This will require from individuals the acceptance that even a initial degree will never be a guarantee that they will be employed in the functions to which they have aspired.

Europe can no longer afford not to make optimal use of the talents of its young people.

4.3. A European investment in human resources, training tools and technology

The following paragraphs include a number of recommendations, in general addressing both the education system and enterprises, which call for action at Community level.

- First of all, IRDAC is concerned that current training systems in Europe are not sufficiently adapted to the changing needs of society. This concerns in particular the updating of trainer skills and qualifications, as well as the development of more efficient training tools and delivery mechanisms based on new technology and innovative teaching and learning approaches. Traditional face to face course formats and lectures have a lot of intrinsic value, but are not the appropriate solution for the quantum leap which is needed in continuing training. Most SMEs cannot afford to send their personnel away for considerable periods of time. It is noticeable that educational productivity and efficiency has not kept pace with the productivity and complexity growth in the rest of society, notably in enterprises. If anything, technology developments currently seem to widen this gap.

  Therefore, a large structural effort in distance and flexible learning is required in Europe. Traditional distance learning systems (such as those of the open universities in Europe) should be assisted in redirecting their actions more towards industrial environments. In addition, new technology itself should be used in the production and delivery of training materials to allow for individualised learning and to increase the efficiency of the training process. IRDAC welcomes the actions under way in various European Programmes (in particular developments under COMETT and DELTA) and the emergence of organisations like EuroPACE, SATURN, EUROSTEP, EADTU), but observes that important obstacles still need to be removed, in particular the complete lack of standardization, the high unit cost of multimedia training products, the inadequate teaching and learning experience regarding their effective use and the insufficient user-friendliness and attractiveness of such packages and systems.

  Overall then, IRDAC urgently calls for improved productivity of education and training wherever it takes place. The European Community should foster educational research and experimentation into effective ways of using information and communication technology in order to obtain the required improvements. This effort for investigating productivity gains through the use of new methods and new technology should be shared between the end users and the professionals of the private sector. The productivity of the economy is dependent on the productivity of education and training. Higher productivity will also require better management of education systems and institutions.

- Secondly, certain skills deficits are so crucial, and require such a large investment (even if it concerns only a relatively small group), that action should be taken in a European framework, respecting of course the principle of subsidiarity. The action with regard to VLSI design skills and the establishment of the EUROCHIP organization is a case in point. IRDAC feels that the number of such areas, in which only a coordinated European approach is cost-effective, will increase. It therefore calls on the Community to analyze the areas which are likely to be concerned, and develop the programmes and actions plans needed. It stresses that these should be integrated within a more coherent European approach with regard to skills shortages, which is currently lacking, partly because of an existing proliferation of programmes and actions.

- Thirdly, IRDAC believes that increased mobility of the workforce, and in particular of higher skilled staff, is beneficial for the overall economic growth of Europe. It will assist in reducing skills shortages in certain regions at certain moments in time. Increased mobility will however require that certain barriers are removed and that the labour force gradually accepts these ideas. IRDAC supports the measures of the European Community to increase mobility of young Europeans, and expresses the wish they would be continued, in particular in areas where skills shortages are acute.

- Fourthly, IRDAC insists on the need for a balanced European investment. Europe should make sure that any additional effort with regard to skills shortages should not create further imbalance and brain-drain within the Community. There is a risk that peripheral countries will become even more peripheral with increased mobility and skills competition in the Single Market. Therefore, the measures to be implemented should avoid such polarization, in particular by exploiting developments in the field of telematics and training technology.

- Fifthly, all European R&D efforts should be accompanied by related training measures, to try to ensure that the required numbers of researchers and "appliers" are available as the programmes develop; otherwise the leverage effect of these programmes risks being severely reduced. IRDAC welcomes the growing attention given to training in the Third Framework Programme for R&D (in particular the programme on human capital and mobility), but suggests that both qualitative and quantitative considerations are built in, related to sectoral priorities.

Finally, balanced European investment in new training provision can be the first step for further developments. It is yet unclear what implications the developments in Eastern Europe will have on the overall skills shortages issue. However, IRDAC believes that if the Community first develops a coherent internal policy, it will be in a better position to assist in these developments as well.

4.4. Understanding skills requirements

The sheer complexity of the skills shortage problem renders approaches and potential solutions complex and difficult to implement. The analysis of the problem by IRDAC has revealed that a better understanding of the issues concerned, their interaction and implications should be developed. In that respect a number of proposals are made.

The work undertaken has clearly shown that there is a clear lack of reliable data on the issues concerned, and where data is available, it is often incompatible and inconsistent. The micro- and macro-level are often mixed up. IRDAC therefore calls for a serious standardization effort in the collection of data relevant to skills shortages, its classification and the projections which are based on it.

- For the European Community and the national governments, this means that consistent and comparable approaches should be developed, to standardize and improve the forecasts and

projections regarding supply and demand of skills. It requires also that research is undertaken to examine in greater depth the complex interrelationships between technological innovation, economic growth and performance, educational attainment and the supply of skills. Such work will then allow long term policies to be developed which are based on an understanding of the mechanisms which lead to skills shortages. It should also permit comparison of Europe's performance with that of other highly industrialised areas.

- At the regional and sectoral level, the need for more and better training needs analysis is also apparent. Regional and sectoral actors should be encouraged together to analyze the supply and demand in their particular environments, and develop remedial actions based on it. This can only happen if a thorough inventory of current training provision is available, as well as an analysis of the demand in a particular region or sector. Much can be gained from case studies and experience in other regions, and the transfer of such experience should be promoted. IRDAC observes that a growing number of actions in this direction are taking place (e.g. studies by DG XIII and the TFHR, training needs analysis by UETPs[26]), but calls for the promotion across Europe, both at regional and sectoral level, of this type of training analysis and forecasts of skills requirements. In specialised areas, much may be achieved at modest cost, by identifying and addressing correctly bottlenecks in the training infrastructure. As an example, the ESPRIT VLSI Design Action has, by providing a solid route to circuit fabrication, given a focus to the whole activity of VLSI design training in Europe.

- All analyses will fail if at the micro-level companies cannot quantify their demand in terms of future qualifications. More companies should be encouraged to develop human resources strategies and to consider training as an integral component of it. It is evident that SMEs, the large majority of European companies, are currently not in a position to do so, since their planning horizons are often extremely short. Also, it is difficult for management in companies to understand the type of skills to be trained. Therefore, serious medium and long term training needs analysis and manpower requirements forecasts are difficult to establish. It is important to help enterprises (in particular SMEs) to forecast better the type and range of needs they will face in the future, so that macro-economic strategies can be developed that are based on more solid ground than is the case now. This is a major challenge, which will take a lot of time. Tools and approaches should be developed that assist enterprises to develop their capacities for a better prediction of skill needs. IRDAC considers that further research work on this topic could prove useful, and recommends that these suggestions are taken up by sectoral professional organizations, both at national and at the European level.

To conclude, IRDAC realises that many of the problems raised and the recommendations proposed, focus on a perceived lack of adequate awareness of the importance of education and training as a strategic weapon in Europe's competitiveness. As its final recommendations it therefore asks that thorough studies should be undertaken at a European scale of the manpower requirements and related training and skills implications in specific sectors which are crucial for Europes competitiveness and that a major study should be undertaken on the cost of non-investment in education, so that European policy makers, enterprises and individuals should realise the challenge that is in front of them.

IRDAC asks the Commission of the European Communities to take up the recommendations made in this report and to propose a coherent plan of action, as well as steps for their implementation. It is recognised that the design of certain existing European Programmes (e.g. COMETT, DELTA, SCIENCE,...) already contributes to some extent to the realisation of some of the recommendations made but needs strengthening. However, certain of the other recommendations need the establishment of new programmes designed in cooperation with Member States.

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[26] UETPs are University-Enterprise Training Partnerships developed under the COMETT Programme.

Annexes

Annex 1 : List of IRDAC Working Party 11 Members

Chairman of the Working Party : Sir Robert TELFORD - The Marconi Company (UK)

Chairman sub-group "Skills Shortages" : Mr. Erik Van BRUGGEN - Fokker Aircraft (NL)
Secretary : Mr. Wouter Van den Berghe

Chairman sub-group "School Industry Interface" : Mr. Francesco MUSTO - Selenia Industrie (I)
Secretary : Ms. Janet Smith

Other members :

(the members of the sub-group "Skills Shortages" are marked with (*))

Mr. Mario BONA - Citta degli Studi (I)
Mr. Damien de CALLATAY (*) - Petrofina (B)
Mr. Anthony G.F. CHAPLIN - Pilkington Plc (UK)
Mr. Xenophon CONSTANTINIDIS (*) - Aluminium de Grèce (GR)
Mr. Pedro CORDOVA - Fundación Centros de Formación y Tecnologia (E)
Mr. Lionel COSSE - Biscuiterie Nantaise (F)
Mr. Keith DAVIES - IBM (B)
Mr. Werner ELLERKMANN - Centre européen de l'Entreprise publique (B)
Mr. Kruno HERNAUT - Siemens A.G. (D)
Mr. Morten KNUDSEN (*) - Teknologisk Institut (DK)
Mr. Pierre LANDRY - Centre de Formation BULL (F)
Mrs. Birgit LUND - Aktieselskabet Hafnia Invest (DK)
Mr. Jean-Marie MELLERY - Olivetti SA Belgium (B)
Mr. Klaus MIDDELDORF (Mr. Klein) (*) - Arbeitsgemeinschaft Industrieller Forschungsvereinigungen e.v. (D)
Mr. Dermott O'COLMAIN (*) - Ericsonn Expertise Ltd. (IRL)
Mr. Jean-Jacques PAYAN - Régie Renault (F)
Ms. Laurien J. POLDER - Shell Internationale Petroleum Maatschappij (NL)
Mr. Fritz RATH (Ms. Theunissen) (*) - European Trade Union Confederation (B)
Mr. Vergilio Rui TEIXEIRA LOPO (*) - Cimentos de Portugal (P)
Mr. Cedric THOMAS - Engineering Employers Federation (UK)
Ms. Marcia TRIGO (*) - Instituto de Inovação Educacional (P)
Mr. Maurice V. WHELAN - Silicon & Software Systems Ltd. (IRL)

Secretariat of Working Party 11 : TFHR, COMETT Technical Assistance Office

Ed Prosser, Wouter Van den Berghe, Janet Smith, Anne Köhler

Commission liaison officials[27]

Robert Jan Smits (DG XII), Richard Delmas (DG XIII), Ricardo Charters d'Azevedo (TFHR)

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[27] Other Commission Officials have attended meetings where appropriate.

Annex 2 : Terminology and glossary of terms

1. Throughout the report a number of terms are used :

Higher education, universities : these terms are used to point to all kinds of establishments in the countries concerned, whatever their official name is, which deliver degrees for which a completion of secondary schools is a prerequisite.

Companies, enterprises, industry : these terms are used for all kinds of organizations and services engaged in economic activity and which recruit from the labour market. In the context of this report they include therefore also public administration, services, self-employed etc.. Note however, that some of the analyses and recommendations point more specifically to private enterprises in the strict sense. "Manufacturing" is often used to denote all sectors of the productive (non-service) industry, including extraction, process and construction industry.

Education, training : these terms are used interchangeably throughout the text for all kinds of formal and informal learning processes, be it in a traditional environment (schools, universities) or less traditional (enterprises, self learning). "Initial education" is referring to the educational process that leads to all post-compulsory educational qualifications up to traditional degrees. "Continuing training" is referring to knowledge acquisition after that first period.

2. Glossary of terms :

BRIDGE	:	Biotechnology Research for Innovation, Development and Growth in Europe (R&D Programme of the EC)
BRITE/EURAM	:	R&D Programme of the EC in the field of industrial technology and new materials
CEDEFOP	:	European Centre for the Development of Vocational Training
COMETT	:	European Community Programme in Education and Training for Technology (Training Programme of the EC)
DELTA	:	Development of European learning through Technological Advance (R&D Programme on training technology)
DG XII	:	Directorate General XII of the Commission of the European Communities (R&D)
DG XIII	:	Directorate General XIII of the Commission of the European Communities (R&D on IT & Telecommunications, Innovation)
EADTU	:	European Association of Distance Teaching Universities
ERASMUS	:	European Community Action Scheme for the Mobility of University Students (Training and student mobility Programme of the EC)
ESPRIT	:	R&D Programme of the EC in the field of IT
EUROCHIP	:	Consortium of organizations coordinating the ESPRIT VLSI Design action in liaison with the EC.
EUROSTEP	:	Association of user of the Training channel on the Olympus satellite
GDP / GNP	:	Gross Domestic Product / Gross National Product
IRDAC	:	Industrial Research & Development Advisory Committee to the Commission
OECD	:	Organization for Economic Cooperation and Development
SATURN	:	COMETT project regrouping actors in the field of multimedia and distance learning
SCIENCE	:	Stimulation des Coopérations Internationales et des Echanges Nécessaires aux Chercheurs Européens (R&D and researcher mobility programme of the EC)
TFHR	:	Task Force Human Resources, Education, Training and Youth

Annex 3 : General References

A variety of sources has been used in the preparation of this report, complemented by the views and experiences of the individual members. Most of the data have been derived from EUROSTAT and OECD sources. Of particular importance and also relevant for further references are the following publications :

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